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Vol. 31. No. 2.

Index to Advertisers and Classified Index Following Reading Matter.

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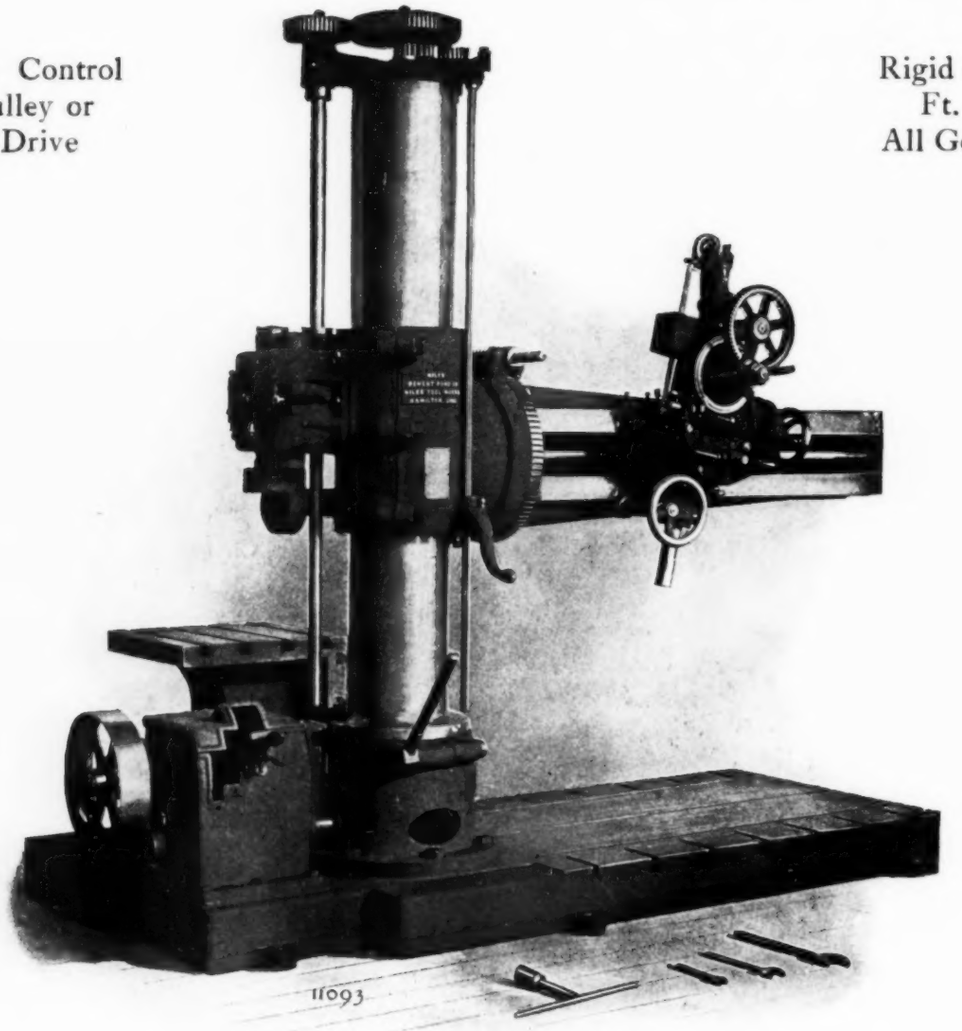

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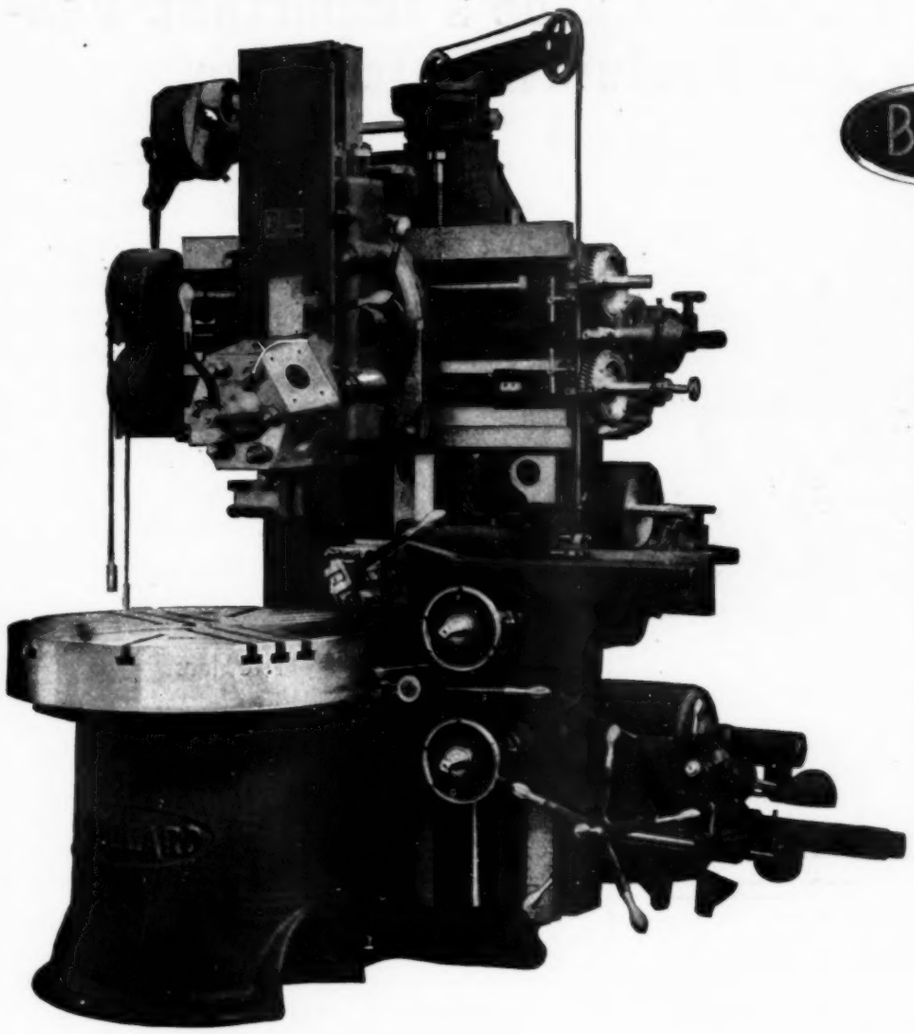

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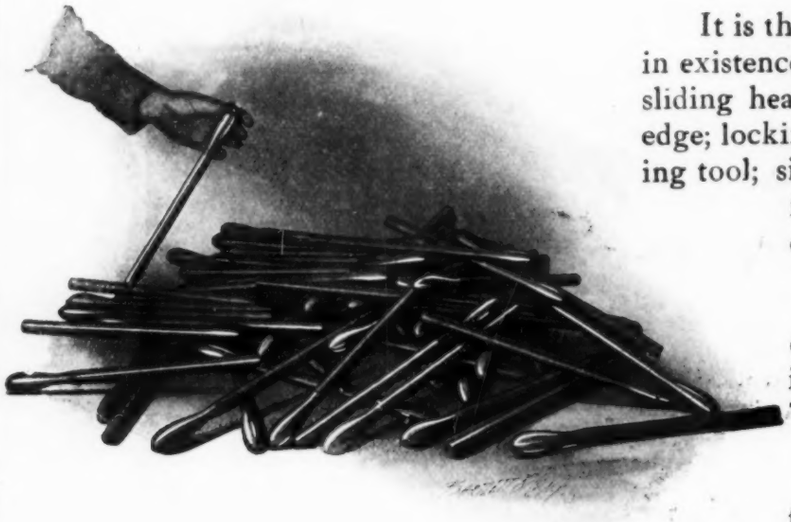

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See pages 12 and 13 for further particulars.

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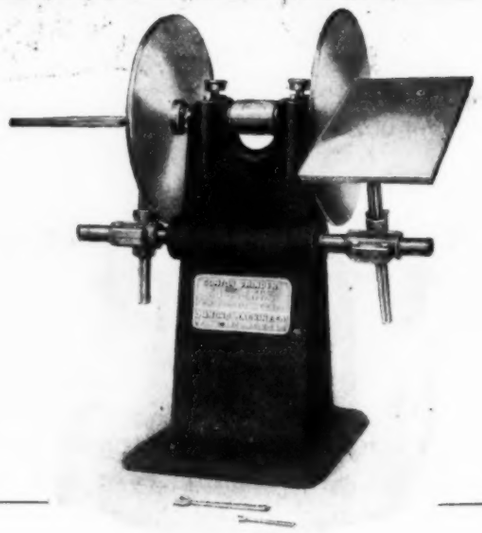

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Interesting Work at Watervliet

Backing Off Hardened Taps by Grinding, Shaping Octagon Holes, Rifling a Gun Slope and Other Work at the Watervliet Arsenal

EDITORIAL CORRESPONDENCE

The Watervliet arsenal is turning out some interesting work in the way of guns of various sizes, and expects to have a hand in the making of some of the new 14-inch wire-wound guns for coast defense.

They have many interesting details in the construction of various parts which go to make up both guns and projectiles; among them is the making of a large order of fuse bushings for projectiles. Perhaps the most interesting feature is the fact that they are manufacturing these fuse-bushings at a considerably lower price than that bid by large private concerns.

The Ordnance Department is endeavoring to keep the cost of manufacturing articles as low as practicable, and therefore ways and means have to be thought out for doing the job economically as well coming within the specifications. Some of these problems are very interesting, as we shall see, and require good mechanical ability to plan and work out successfully.

Fuse-bushing Tools and Output

Taking up a simple job at first, we find the fuse bushings made from machinery steel, cut from the bar to proper lengths. They are shown, together with the tools used, in Figs. 1, 2 and 3. In Fig. 1 the blank is at the left, the tools in the center and plain bored bushing at the right, before tapping.

FIG. 1. THE TOOLS USED FOR BORING THE BUSHINGS
FIG. 2. THE TAPS AND THE FINISHED BUSHINGS

A Bullard boring mill is used, as in Fig. 3, the work being held in a split chuck shown in the center of the table. The small pilot drill is used first, then the 1¾-inch high-speed drill, shown with the two heavy chips coming out of the bushing. This feeds an inch a minute, going through the blank in 4½ minutes. Then the flat roughing cutter cuts out most of the remaining stock, while the two finishing reamers and the necessary tool, with its two cutters undercut for the taps to break through. This operation is finished in an average time of 22 minutes.

They then go to the engine lathe, shown in Fig. 4, which has been fitted up with a turret and releasing holders for the four taps, a roughing and finishing tap being used for each size.

The operation of tapping is quite interesting. The first tap is swung into place and the turret carriage locked to the main carriage by the socket wrench shown behind pilot wheel, making both move together. The feed nut is locked on the screw and taps fed in to insure the right lead and a good thread. A device, shown at the right-hand end of the main carriage, unlocks the nut from the screw and at the same time the turret slide strikes the stop shown under bushing chuck, which allows the tap holder to draw off the tapping heads when the

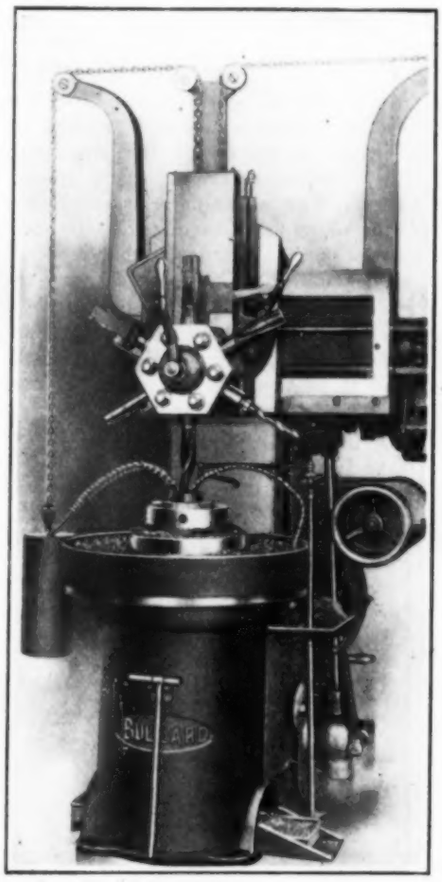


FIG. 3. DRILLING THE BUSHINGS AT THE RATE OF AN INCH PER MINUTE

proper depth is reached. The taps are backed out with the pilot wheel.

Another split chuck, secured in a very substantial way to the lathe spindle is used for holding these bushings for the tapping operation. This tapping operation is completed in 10 minutes.

The taps and a tapped, as well as a finished bushing are shown in Fig. 2. Fig. 5 shows the working drawing of the bushing, with all dimensions and limits. The blanks are only 3 5/16 inches, which leaves a very small finishing margin for the end.

The outside turning is done in 12 minutes and the thread chased with a Rivett-Dock threading tool in 22 minutes. All threads are left-hands.

The additional work, slotting the head and inspection, brings the total time up to 98 minutes, which gives a low labor cost when the amount of metal removed is considered.

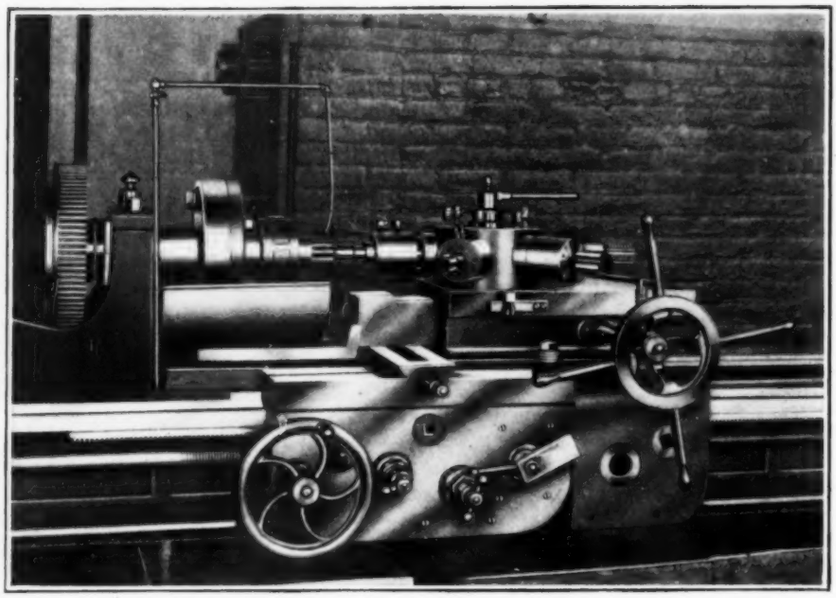


FIG. 4. LATHE RIGGED FOR TAPPING FUSE BUSHINGS

Backing Off Taps with a Grinder

In connection with this job there is a very interesting device used to grind the clearance in thread of the taps used. This is shown in Fig. 6, where a small Crocker-Wheeler motor is mounted on a frame bolted to the carriage of a Hendey-Norton lathe, to drive the tool-post grinder shown. The arbor carrying the wheel is at an angle of 15 degrees from the lathe center, as seen in Fig. 7. This allows the side of the wheel next the lathe head to be trued by fastening the small diamond mounted in the end of the brass holder *A* and working on the outer edge *B* of the wheel. The same diamond is used in truing the other side.

For truing the other side, the little device shown in the tail spindle is used. The end of the piece is 30 degrees from the cross slide and carries a sliding block in which the holder carrying the diamond is screwed. A knob projects through the top and the diamond is passed over the bevel of the wheel, truing it as shown. The section of thread shows how the sides of the wheel come to make the angles right.

This grinding rig is mounted on the regular backing-off attachment for taps, and the taps are relieved after hardening. Either carborundum or alundum wheels are used, of from 100 to 150 grit, and the device makes a very fine cutting tap.

A Novel Way of Backing Off Twist Drills

Another job which grows out of the fuse bushing is the making of the large high-speed twist drills used in the boring mill. These are milled in the regular way with the spiral head on the milling machine, the novel feature being the use of a conical fluted milling cutter, as shown in Fig. 8. This is ¾ inch on the point and has an angle of 15 degrees with the center. It backs off all drills from ¾ to 2½ inches.

It is used in a spiral head, as shown, with the mill set so the heel of the mill will cut before the point and in this way

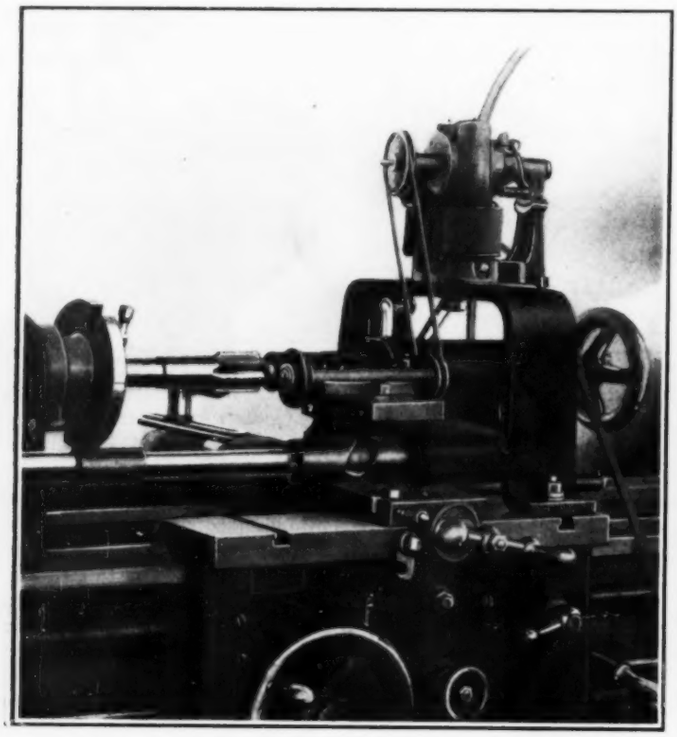


FIG. 6. GRINDER FOR BACKING-OFF TAPS

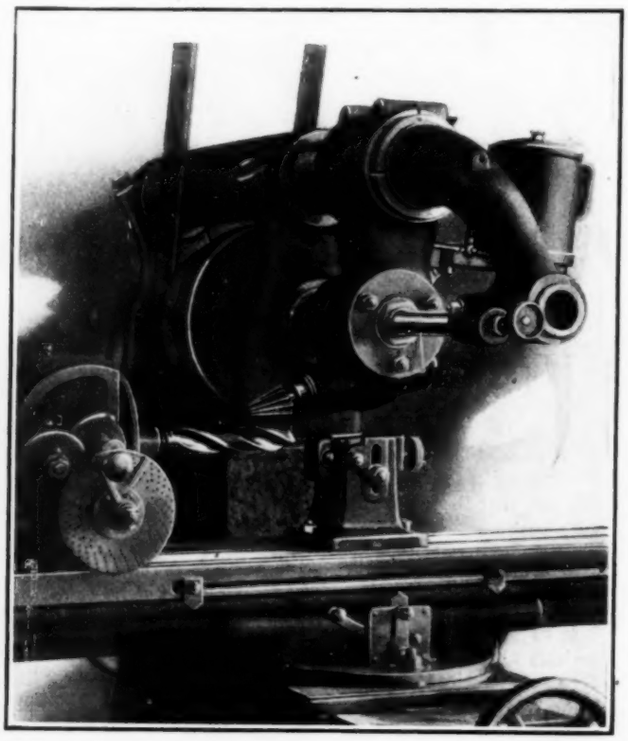


FIG. 8. BACKING-OFF TWIST DRILLS

obtain an eccentric relief. This saves the expense of making milling cutters for relieving each size drill and does a good clean job.

It is interesting to note the way in which these drills are hardened. A tube is provided but little larger than the drill; after heating to the proper temperature, it is inserted in this tube. At the same time compressed air is admitted to the tube, and the result is said to be very satisfactory.

Making Soft Caps for Projectiles

The latest idea in projectiles is to have a soft nose or cap for the sharp point, to prevent glancing and to sort of grip the armor plate of an opposing fleet while the projectile proceeds to go through the soft cap and the armor plate at the same time.

For the 10-inch projectiles the caps are 5½ inches in diameter and are turned from the long bar in the rapid-reduction, motor-driven lathe shown in Fig. 9. High-speed steel tools are used and the caps turned at a rapid rate, leaving the projecting rings, as shown clearly in Fig. 11. They are cut off and the end coned before going to the vertical lathe or boring mill, in Fig. 10. The caps are fastened in the clamp shown; the first operation is drilling, the others following in the order shown.

In the meantime the projectiles have been grooved at the proper distance from the point by grinding. An indication of the hardening strains is the tendency for cracks to develop during the grinding, due to the heat generated.

After the projectiles and the caps have been prepared, they are brought together, the projectile mounted in an old lathe with the tail center holding the cap in place, and a pneumatic hammer drives the lip into the groove so rapidly and completely that one revolution is required to fasten the cap firmly in place.

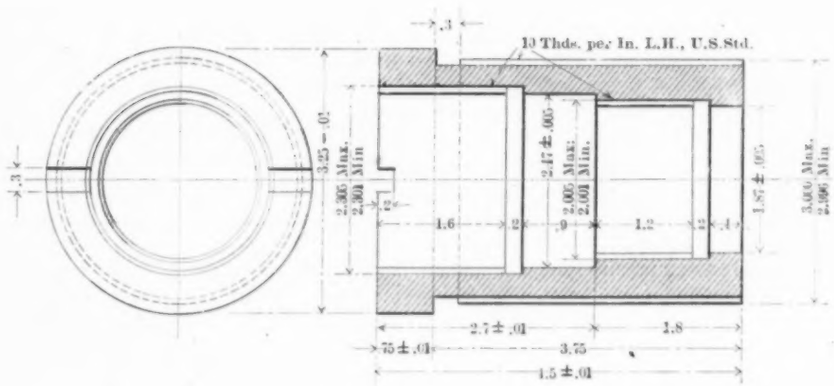


FIG. 5. DETAILS OF FUSE HOLE BUSHING

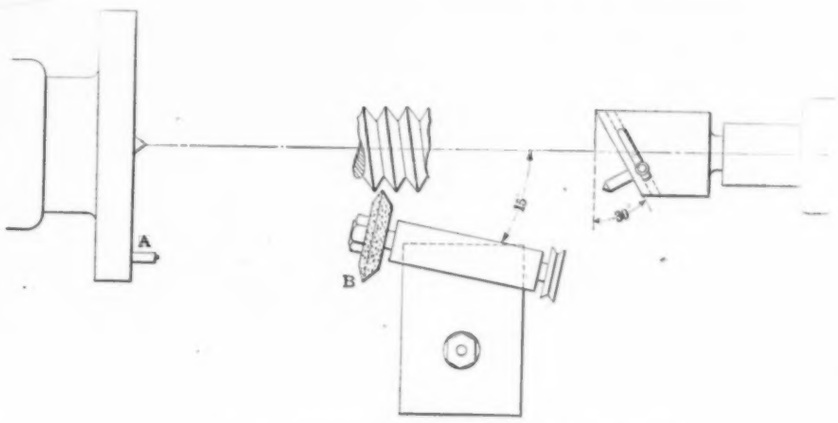


FIG. 7. FIXTURE FOR GRINDING RELIEF ON TAPS

Well Supported Milling Cutters

The 3-inch rapid-fire gun affords two operations of interest, to say nothing of the breech-block mechanism, which is always attractive to a mechanic. The milling of the body of the gun gives one of the best examples of supported milling cutters that I know of.

The cutter arbor is held at the lower end by the substantial arms shown, and these are supported against the outward thrust of the milling cutters by the stop block fastened to the heavy T-rail bolted across the two uprights of the milling machine. The cutters are sectional, ground to the correct radius; the gun can be revolved by the worm shown at the extreme left. The pan under the cutters allows plenty of lubricant to be used without getting it all over the machine,

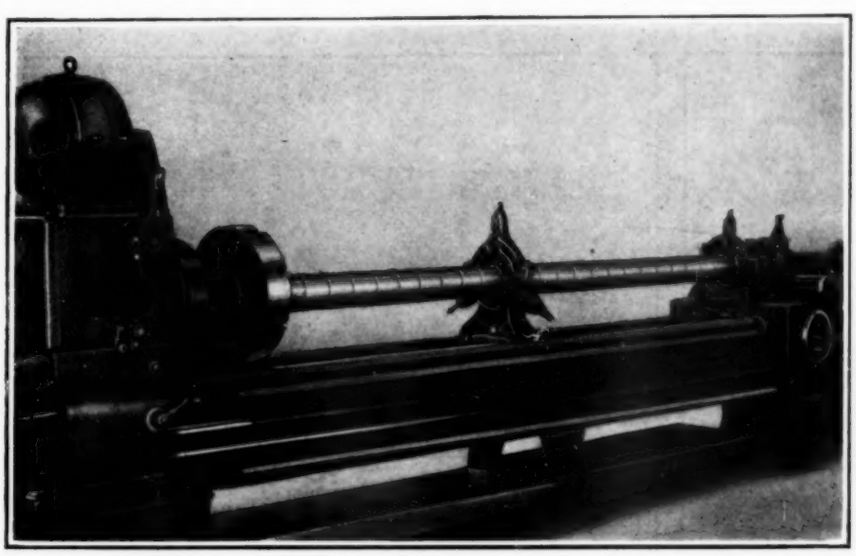


FIG. 9. TURNING SOFT NOSE CAPS FOR PROJECTILES

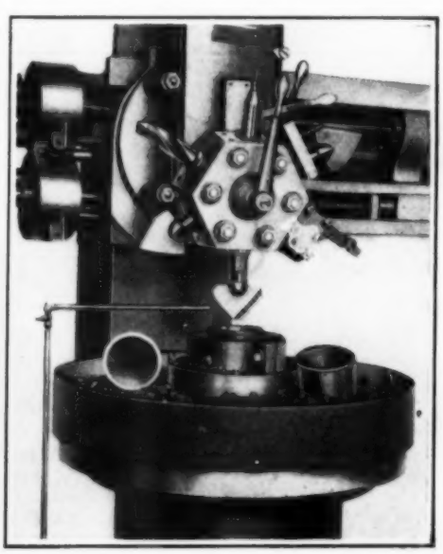


FIG. 10. BORING THE SOFT NOSE CAPS

as the small pump shown at the left of the milling cutters draws its supply from this same pan.

Cutting an Octagon Hole

On this same gun is a recoil lug which has an octagon hole that must be machined to 2⅝ inches across the flats and 3½ inches long. The method of doing this is shown in Fig. 13: The hole is first bored round to the required diameter, 2⅝ inches, and then the two brackets placed in position in the recoil slide as shown.

The rear bracket has a bushing with an octagon hole through which the shaper ram slides. This bushing is located by a key so that it can be taken out and replaced accurately. This is for indexing the work; by slipping out the bushing, turning the ram an eighth turn, the tool is in position to cut another side.

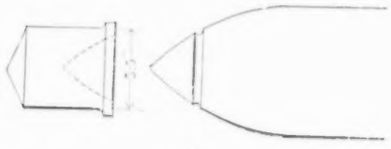


FIG. 11. THE SOFT CAP AND THE PROJECTILE

The cutting end of the ram is shown in detail in Fig. 14. The end is oval to allow it to feed sideways to cut the full width of the flat. The tool is held in a small clapper box on the end of the head. This oval head is fed across the end of the bar by the hand screw shown and is stopped at each end by the two fillister-head screws shown. The end view in Fig. 14 shows the amount of stock removed and the shape of the cutter head.

The gun is mounted across an old horizontal boring machine, and the slotting bar is driven by an eccentric on the end of a shaft, driving through a flat bar. The whole thing is a very neat device and does an excellent job.

Rifling a Ten-inch Gun Slope

The bore of 10-inch guns has what is known as a "slope" at the back end just ahead of the powder chamber. This slope is 30 inches long, and the slope is only 0.04 inch in that length, 0.02 inch on a side. Seems like too small an amount to bother with on a gun of this size, but the science of gunnery demands that the rifling be the same depth on the slope as in the barrel and continuous with it, so the rifling head shown in Fig. 15 was designed to accomplish it.

The upper view shows the cutting tool collapsed so as to be withdrawn through the gun for the next cut, while the lower

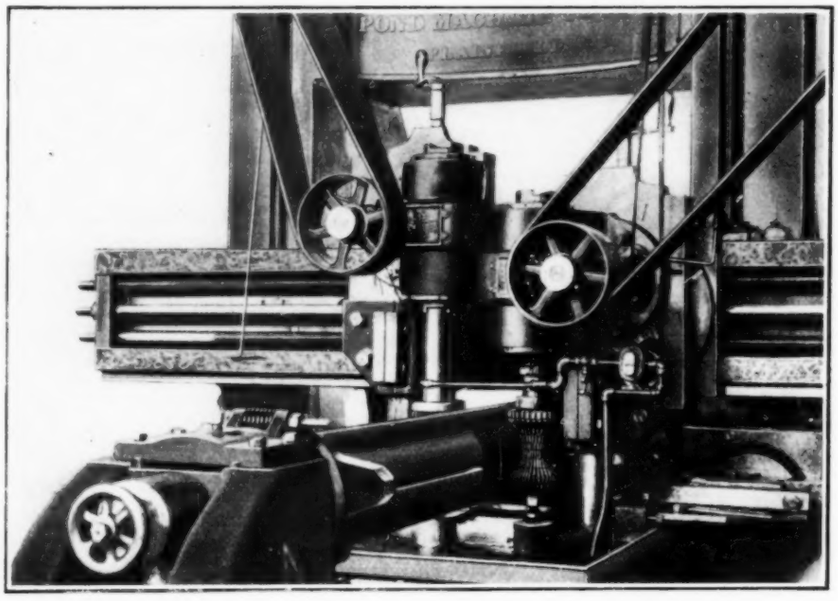


FIG. 12. MILLING BODY OF RAPID-FIRE GUN

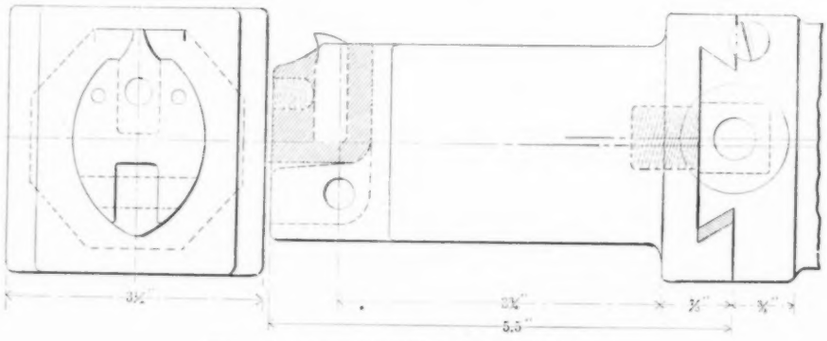


FIG. 14. SLOTTING HEAD FOR GUN LUG

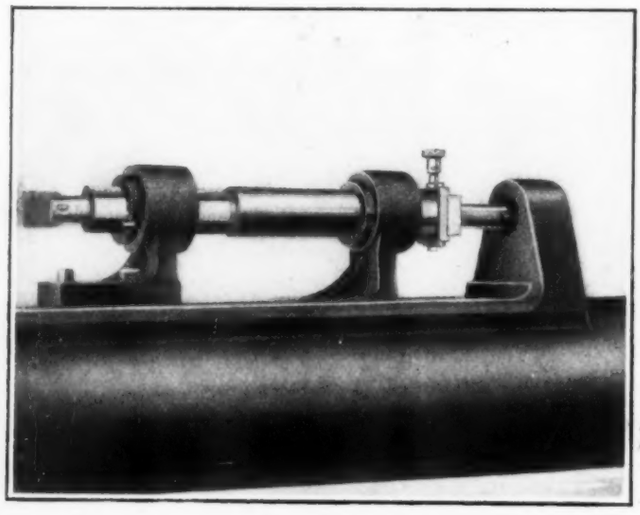


FIG. 13. SLOTTING BAR FOR GUN LUGS

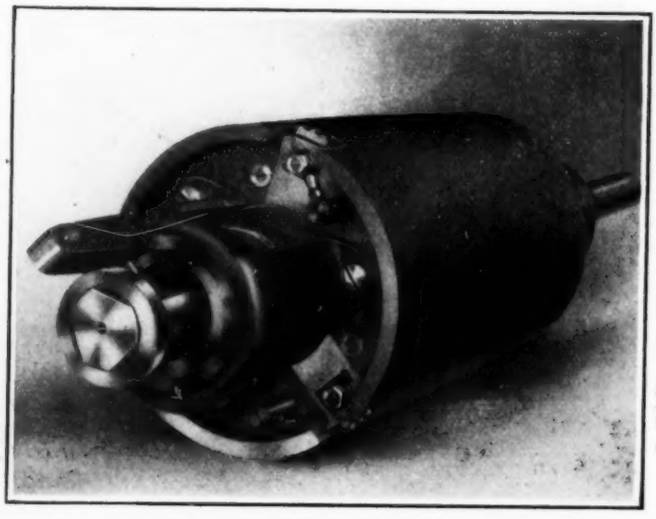


FIG. 15. RIFLING HEAD FOR 10-INCH GUNS

view shows it in cutting position. The tool is fed in from the muzzle so that it must move outward when the beginning of the slope is reached. The taper of the wedges *B*, of which there are three, as can be seen by the end views, has nothing to do with the slope, but only feeds the tool into the cut and withdraws it on the return stroke. The operating bar in the center is the one that gives the taper of the slope. The bar itself is round, so as to fit inside the nuts, but it has three flats planed on it which are the same taper as the slopes of the gun. These flats have a T-slot which controls the wedges *B* positively in both directions, as can be seen in the end views.

The small end of the operating bar is at the right, inside the rifling head, so that in starting a cut the bar is pulled out all the way, bringing the small end of the bar under the wedges, this being the position for the main bore of the gun. At the same time the adjusting nut *N* is pulled back so that latch *L* catches it and holds the collar fast against the shoulder to maintain the cutting tools *I* in their position during the stroke.

When the tools reach the beginning of the slope, the left or large end of the operating bar strikes a stop; as the cut proceeds, the wedges are forced outward as they slide along the bar, carrying the tools with them. At the end of the operating bar is the pin *P;* as the tools reach the large end of the slope, this pin lifts the latch *L*, releasing the adjusting nut *N*. This is then forced in, carrying the wedges *B*, which draw in the tools to the collapsed positions so the bar can be returned for another cut.

The depth of cut is regulated by turning the adjusting nut *N* on the threaded sleeve which controls the wedges; this is divided so as to give a micrometer reading and secure just the desired cut.

A good idea of the whole rifling head is seen in Fig. 16, with the operating bar in and the tools collapsed for withdrawal. The outer casing is of bronze, which soon becomes scored from the rifling and plainly shows the twist of the grooves. Each cutter is flooded with oil from the small nozzles shown.

After the three rifle grooves have been cut by each of the three cutters, the head is turned by an indexing device having 10 divisions, as these guns have 90 grooves in all.

We are indebted to Colonel McNutt, Captain Allen and J. F. McCormick, tool room foreman, for the information and illustrations.

Reporting from Hanover, Consul Robert J. Thompson says that a newly invented refrigerating apparatus, a model of which has recently been privately exhibited in that German city, promises good results. The device is an extremely simple and inexpensive affair, costing perhaps not more than $1 to manufacture. It consists of a double-wall tin vessel with a capacity of 5 gallons or more. There is a hollow space between the two walls, or inner and outer vessels. This space completely surrounds the inner compartment and is about an inch in width. By the graduated admission of carbonic acid to this surrounding chamber at the bottom of the vessel, and from this surrounding chamber into the vessel proper at the top through a cross-armed tube, the contents of the vessel are frozen quickly and completely. Water is changed into ice in the space of sixty seconds. Meats, fruits, bottled beverages, may be chilled or frozen in a few seconds.

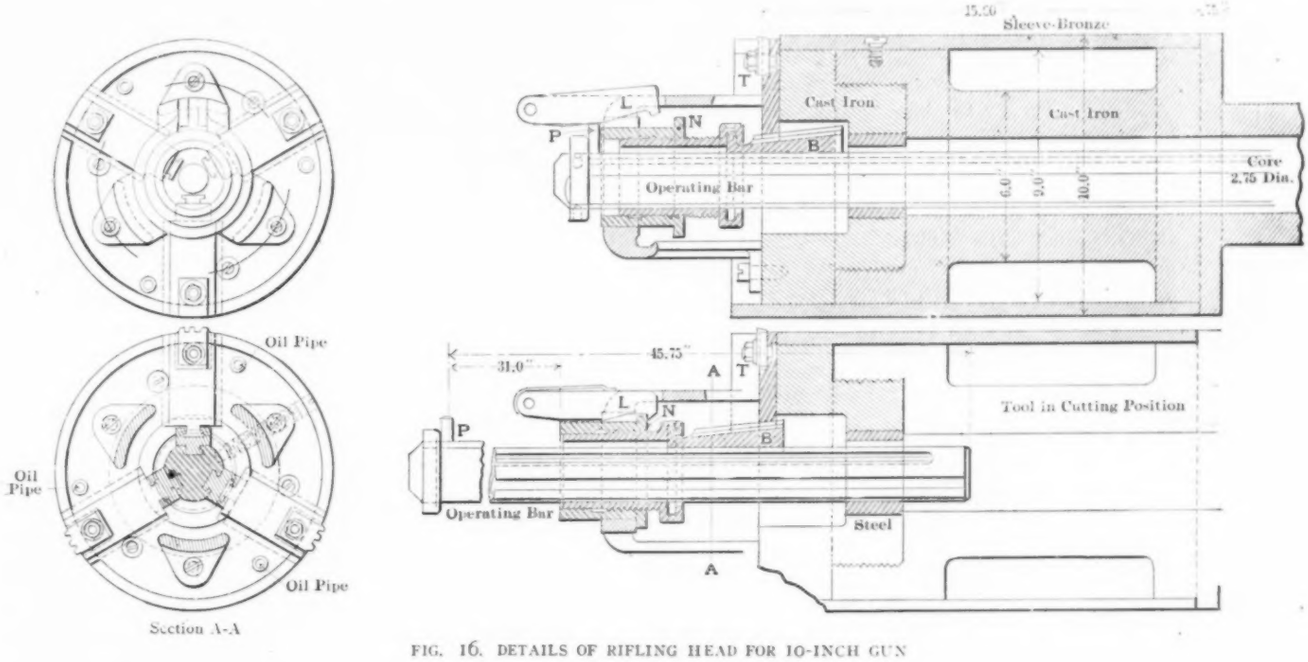


FIG. 16. DETAILS OF RIFLING HEAD FOR 10-INCH GUN

Legal Knowledge for the Superintendent

By Oscar E. Perrigo

The successful machine-shop superintendent must possess a fund of information on a variety of subjects that are not, strictly speaking, in his particular line of work. We are liable to think that if he is a good mechanic, knows shop systems and methods, is well posted on materials of construction, understands handling men so as to get a good quantity of work of a good quality out of the force, at an economical expenditure for the payroll, and isn't bothered with labor troubles, he will get along pretty well. To be sure it is getting rather a fad to require that he be technically educated, and in some instances if this condition is satisfactorily met the parties are willing to overlook some shortcomings as to the other qualifications.

To the man who takes a broad and comprehensive view of the question, all the qualifications enumerated above are good and desirable. But there are others quite as necessary, often included in the man who can make good in the conditions as given, and by reason of which he does prove to be the right man in the right place. These qualities are good sound common sense, good judgment, and logical deductions from a certain array of facts, circumstances and conditions, and the ability to select the right man for a certain duty, and to give him clear and unmistakable orders which he is to follow in doing that duty. Here comes in, not only the knowledge of the particular business in hand, but a general knowledge of

business on broad lines, and also a knowledge of human nature and an executive ability, without which no man in a similar position can hope to be successful.

Yet with all these qualifications there is still another phase that must not be neglected, and which is very seldom mentioned or considered. This is a general knowledge of the principles of common law. To possess this even in a limited degree will greatly simplify many of the problems which the superintendent must frequently meet and solve.

A comparatively simple case occurring under the observation of the writer a few years ago will illustrate the point and show the value of a little legal knowledge of a practical kind.

In a city of a hundred thousand inhabitants were a number of machine shops turning out a variety of products. One of them was equipped with comparatively large and heavy machines, and frequently "to help out their neighbors," took in jobs that were too large for the other shops to handle.

One of these occasions was that of planing and boring a large press casting. An excellent blue print had been furnished from which the work was to be done. When the man who ran the "big planer" got ready for the job he measured up the casting, laid off his center lines and centers, then the holes so as to "divide the stock" and after repeated trials decided that the casting (which was a first one from a new pattern) would not "work up to the drawing." Instead of taking the responsibility of varying the work from the dimensions laid down on the blue print, as he would probably have done if it was his own work, the superintendent took the legal course and promptly notified the company who had sent in the job, and received a reply that they would send a representative to arrange the matter.

The representative came, not one but two, one an experienced and very agreeable gentleman who had designed the press, and the other a young draftsman who had made the drawings of it. After going over the "lay-out" on the casting these gentlemen decided to have an important shaft hole bored considerably larger than called for by the blue print, in order to save the casting.

In due course of time the work was completed and sent out of the shop and later on, a bill was rendered for it. Nothing was heard of this for several months, and when the collector at last called for a check for the bill he was met with a claim for a considerable rebate representing expenses incurred in consequence of the work not having been done according to the blue print furnished. This called for an explanation from the superintendent which was made in accordance with the facts, and again the matter rested so far as he was concerned.

Somewhat later the manager sent for the superintendent and requested him to take charge of the matter and "get some kind of a settlement." Then he undertook an investigation of the matter in a quiet way and when he had established these facts, and as he thought, his case, he made appointment with the manager of the firm for whom the work was done, who by the way was a high city official and had studied law. On the day appointed the superintendent called and very soon became painfully aware that "the other fellow" had been "preparing a case too." In fact the inquiry into the matter took the form of an official investigation at which the legal gentleman presided. His witnesses appeared duly armed with records to show that with due forethought and a desire to gain time, various parts belonging to the machine had been made while the work on the big casting was going on in the superintendent's shop. Records as well as witnesses established these facts. Also, that when the casting was received these parts could not be used in consequence of the fact that the casting had been finished differently from the dimensions given on the original blue print. Then the witnesses and records showed the amount expended in making new parts, and this was the amount claimed as an offset to the bill for work on the casting. The man in charge of the shop where these parts were made had made a good showing and "rested his case."

In answer to this the superintendent stated the facts of having reported that the casting would not finish up to the blue print, and of the visit of the two representatives who gave the order for the changes "to save the casting," and asked that they be called as witnesses. Much to his chagrin he was informed that the old gentleman had died while the work was in progress on the big casting and the young draftsman had quit and gone west and his whereabouts was not known. This condition made a sudden draft on his legal resources and some quick thinking was needed to save the case. He asked that the man who had charge of the shop be called again. As the manager considered his case won he was very ready to grant what he considered was the superintendent's "last request" and the following evidence was secured.

"Did the representatives of your company inform you that they had ordered changes from the original blue print?"

"They did not."

"When did you first discover that the casting had been finished to different dimensions from those on your blue prints?"

"Why, the casting had laid here for two or three weeks, I think."

"What did you do when you found that the casting was not finished according to your blue print?

"I told the chief draftsman that our stuff was no good, and as we didn't want to lose the casting he must change his drawings and we would make new parts."

"Then you considered that our company had done our work wrong?"

"Why, of course you had."

"Did you in any way notify our people that our work was wrong and that there would be a bill of expense in making new parts in consequence?"

"No, I did not; we had to make them any way."

"That is all. Mr. Manager we claim the full amount of our bill."

The manager realizing the legal point as well taken turned to his bookkeeper and said, "Make out a check for the full amount," which he did and the superintendent had the satisfaction of presenting this check to his surprised principal on his return from "the trial."

Moral: If you are running a shop, and find the work of another shop wrong, don't make a bill of expense on it until you have notified the other fellow and given him an opportunity to correct his errors or supposed errors if he so desires.

An Efficient Oil-handling Equipment

SPECIAL CORRESPONDENCE

To meet their own particular requirements in the matter of oil storage is a serious problem to many manufacturers who use oil as lubricant, in the process of manufacturing, or as component parts of their finished product. This is a situation true of many machine shops where separate supplies of oil must be carried in store for the power plant, general machine lubrication, machine cutting operations, the painting room and other departments. This problem seems to have been satisfactorily solved in the plant of Theodor Kundtz, a large manufacturer of sewing-machine cabinets, at Cleveland, Ohio. Here engine oil is used for lubrication, and turpentine, benzine, boiled linseed and rubbing oil for finishing the cabinets. While very little machine work is done here, still the general principles of the oil-handling equipment are directly applicable to machine-shop requirements.

In planning the system for this factory, the following requirements had to be taken into consideration: First, tankage sufficient for all the oils to be purchased and delivered in car lots and yet occupying the small amount of space available close to the railway sidings for convenience in filling; second, a means of distributing the oils to the varnish-thinning room and other departments. In the varnish-thinning room, turpentine, benzine and boiled linseed oil are used in large quantities, and all of the oils are used in smaller quantities in other departments. All the oils must be handled with the least possible amount of labor and without disagreeable and dangerous features which so often attend their use. All these re-

quirements seem to have been met by a system manufactured and installed by S. F. Bowser & Co., Inc., of Fort Wayne, Indiana.

There are six heavy steel tanks located in the basement. See Fig. 1. They are all of 8000 gallons capacity, cylindrical in shape and set up on end, so as to occupy the minimum amount of floor space. There are two tanks for turpentine and one each for boiled linseed oil, benzine, rubbing oil and engine oil. Fill pipes run from the tanks to a point convenient to the railway siding, so that a direct connection can be made with the tank car and the tanks filled in one operation. All of these oils are drawn to the first and second floors of the plant by means of long-distance pumps. These pumps are a combination suction and force model and are very powerful, being capable of drawing oil to a great distance and hight. They handle the heavy paint oils as easily as engine oil, and do not become gummed or clogged. They are self measuring, that is, they measure and discharge at one operation gallons, half gallons, quarts or pints at the option of the operator, thus doing away with measures and funnels. Fig. 2 shows some of the pumps arranged for hand operation, and Fig. 3 a second battery, arranged for power operation, which are described below.

For mixing the oils with the varnish in the varnish-thinning room, three automatic self-measuring power pumps are used, connected with the turpentine, benzine and boiled-linseed tanks. This pump, as its name signifies, is operated by power and is also self measuring; it will accurately deliver any required amount of oil directly into the mixing vat. When one pump is set for forty gallons of benzine, and another for fifty gallons of turpentine, no other attention is required, for the pumps automatically stop as soon as the desired amount of oil is discharged into the vat. These pumps accurately measure and discharge any desired quantity from one to one hundred gallons and the oil is pumped at the rate of from fifteen to twenty gallons a minute. A two-way nozzle is provided with these pumps, so that the oil may be discharged directly into the mixing vat or turned into some other receptacle, without making any disconnections.

This equipment has now been in use for some time and has met every requirement. It is safe, for the method of filling the tanks and the elimination of measures and funnels precludes the possibility of oil-soaked floors and vapor-laden atmosphere. This system is also economical, for every gallon of oil bought is accounted for—evaporation, contamination, leakage and waste being prevented. In the matter of convenience and cleanliness this system is also to be recommended. The tanks are easily and quickly filled, and the pumps are placed where the oil is used. There are no dirty barrels, oily funnels and measures, oil-soaked floors and cotton waste to be seen around the plant. Everything is as clean as if no oil were handled.

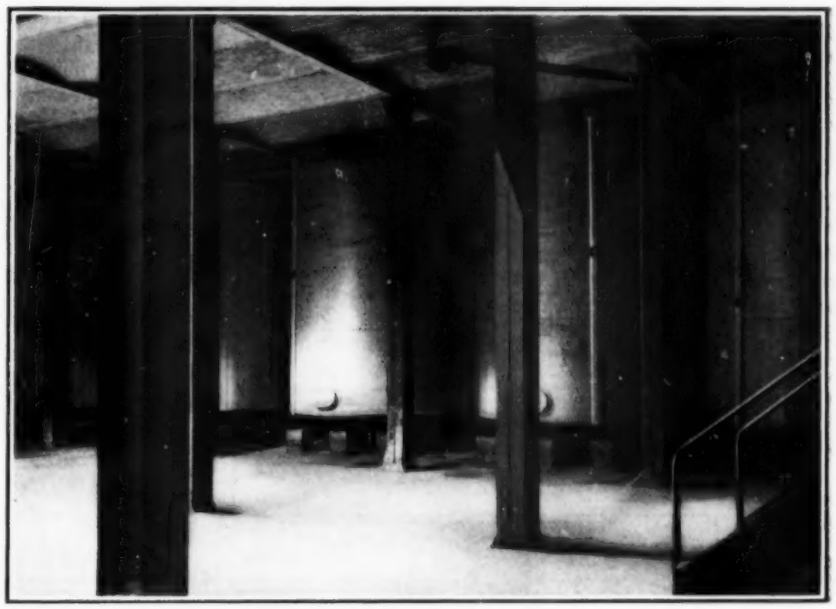


FIG. 1. THE OIL STORAGE TANKS

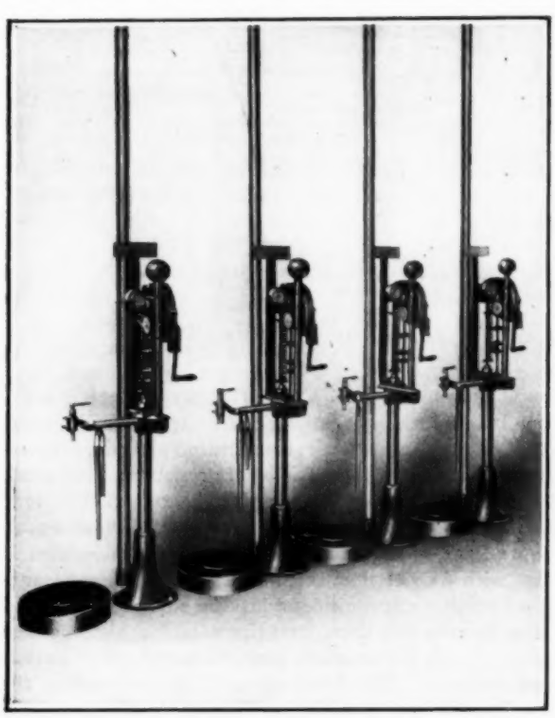


FIG. 2. A BATTERY OF SELF-MEASURING HAND-OPERATED OIL PUMPS

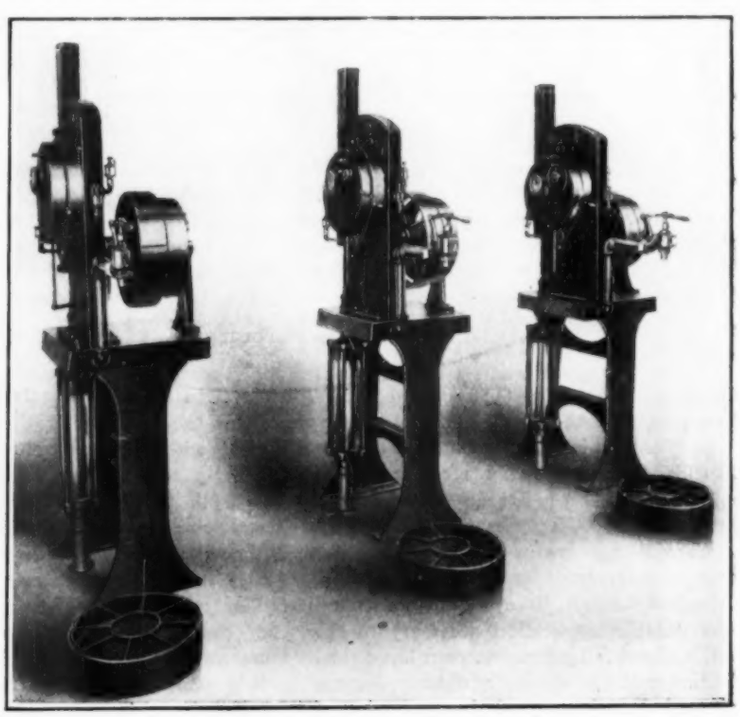


FIG. 3. A BATTERY OF SELF-MEASURING POWER-OPERATED OIL PUMPS

Compressing Air by Tidal Power

By William O. Webber

It has been erroneously stated that the Rockland Power Company, of Rockland, Me., is making experiments in the use of the Taylor system of air compression to compress air by tidal power. The plants at Norwich, Conn.; Victoria mines, Rockland, Mich.; Magog, Quebec, and Peterboro, Ont., embody the Taylor system The plant which is in contemplation at Rockland, Me., is really a return to the older methods of Frizell, with modern improvements.

Careful experiments upon a large working model erected at South Thomaston, Me., last summer, have fully demonstrated the peculiar application necessary to the utilization of the flow between large tidal basins and the ocean, and have demonstrated that an economical compression of air can be accomplished with much less differences in water level than was claimed by Frizell. At South Thomaston, Me., there is a tidal basin with an area of slightly over a square mile. The average rise and fall of the tide at this point is 10 feet. This would, therefore, realize about 5000 horse-power on the basis of 75 per cent. efficiency of the compressing apparatus, which should be easily obtained, as the tests of the other plants mentioned have given much higher values.

The "head of fall," or the difference of level in the case of tidal flow, simply governs the ratio of air that can be entrained with a given volume of water, and has nothing to do with the pressure. The depth below the surface at which the separation of the entrained air from the water takes place, governs the pressure, and it has been demonstrated that with a fall of 35 feet the highest ratio of efficiency can be obtained, that is, the maximum ratio of air to water.

It is easily practical to arrange for storage chambers, connected with the separating chamber, sufficiently large to store air to the average capacity of the compressor, to cover the period of time at flood and ebb tide when the compressor would either not work at all or at such low efficiencies as to be commercially impracticable.

Contrary to the usually preconceived notions it is practicable to transmit compressed air through pipes to long distances with comparatively slight losses. It has been demonstrated by the Popp system, in Paris, that the leakage is very slight, and the four years' experience at Norwich, Conn., that the leakage is practically nothing. As hydraulically compressed air contains no entrained moisture, the frictional resistance in good, smooth-coated pipe is remarkably low, and velocities of 50 to 70 feet a second are admissible. The cost of pipe lines is not greatly in excess of electrical transmission lines when the cost of step-up and step-down transformers for high voltage is taken into consideration.

There are many tidal basins along the coasts of the temperate zones between the fortieth and fiftieth parallels of latitude which are commercially capable of devel-

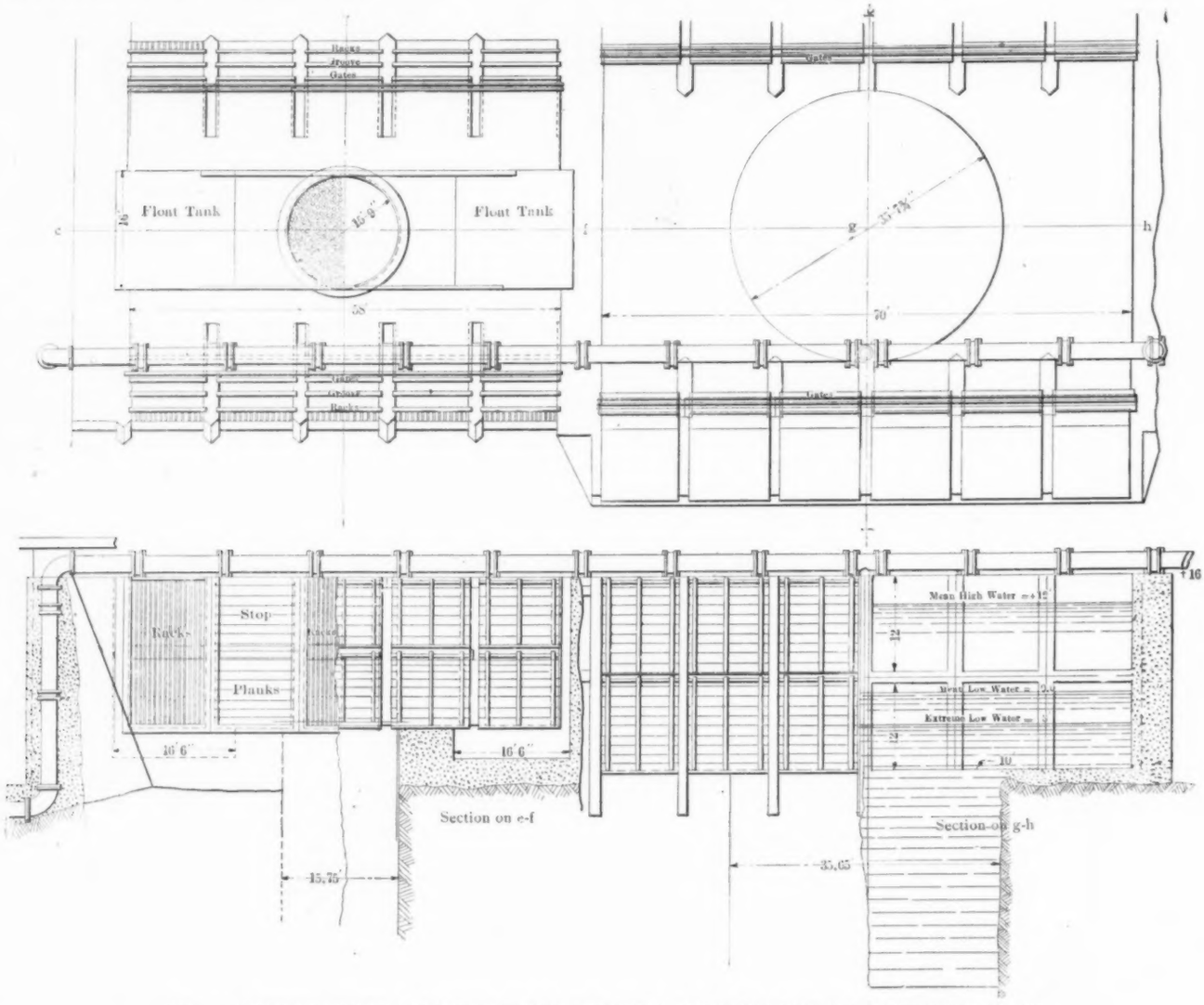


FIG. 1. DETAILS OF INLET AND OUTLET TANKS AND TUBES, ROCKLAND TIDAL AIR COMPRESSING PLANT

opment in this manner with an unfailing source of power, which has no dry season in the summer and which the cutting off of forests does not affect. This power can be made available for many miles inland from the shore at a comparatively low cost and, with the single exception of lighting, can be turned into useful work in its original form in strict competition with electrical power.

Work will begin at Rockland early next spring on the construction of the dam, laying the pipe lines to the quarries of the Rockland Rockport Lime Company, to the power house of the Rockland, Thomaston & Camden Street Railway and also to several cities in whose streets distribution mains will be laid the same as gas pipes. It is expected that the plant will be completed in the fall of 1908.

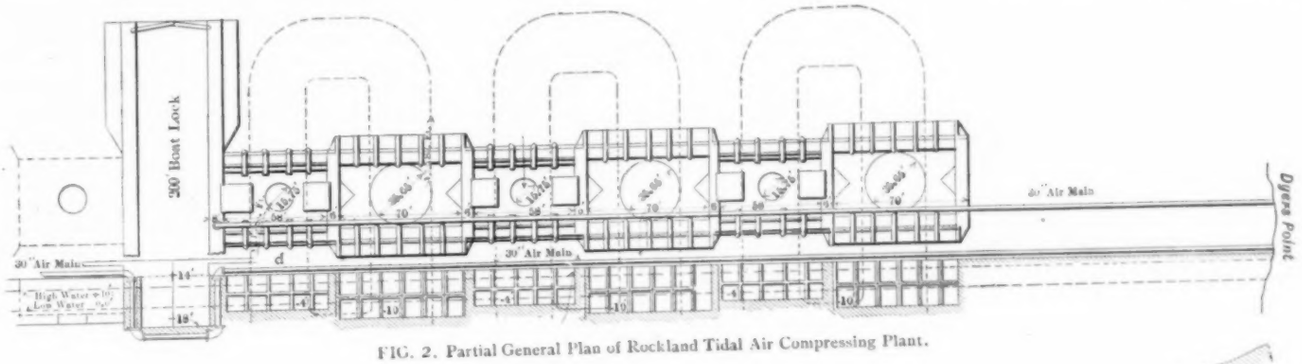


FIG. 2. Partial General Plan of Rockland Tidal Air Compressing Plant.

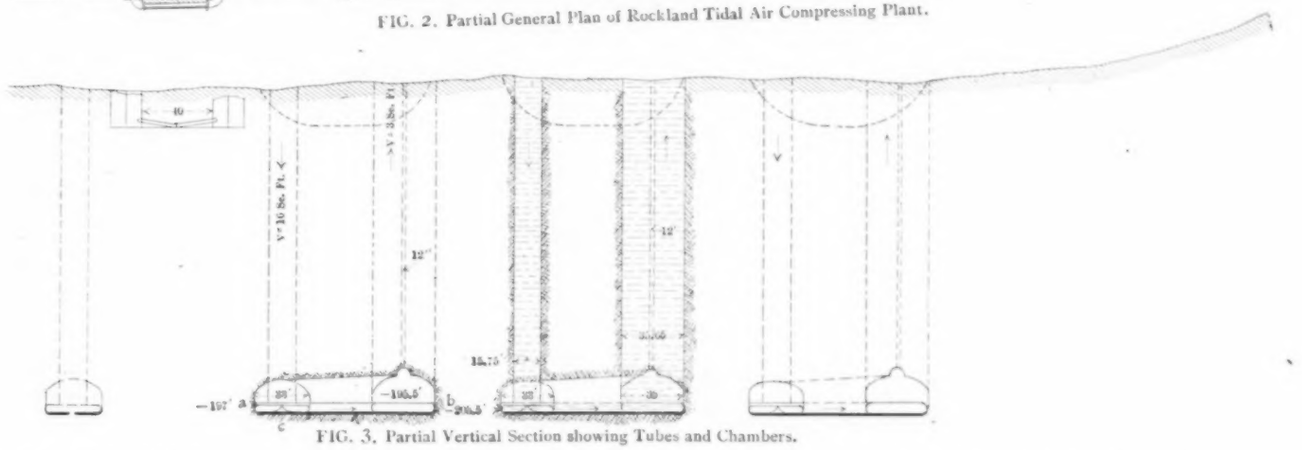


FIG. 3. Partial Vertical Section showing Tubes and Chambers.

The Rockland Development

Fig. 1 shows details of the lock and inlet and outlet gates, Figs. 2 and 3 a partial general plan and sections of the complete construction at the same point. The maximum tide is 10.6, mean tide 9.4 and minimum tide 7.9 feet, giving, respectively 5000, 4000 and 3000 horse-power. In this dam, where the main channel is navigable, will be a lock for vessels 40 feet wide by 200 feet long and 28 feet deep. On either side of this lock will be one or more sets of shafts, each set making a unit or compressor of 1000 or more horse-power. These shafts will be sunk into the rock to a depth of 203.5 feet below mean low water, the downflow shaft being 15.75 feet in diameter, the upflow shaft 35.65 feet in diameter. The inflow gates will be five in number and 10 feet wide. The outflow gates will be six in number and 10 feet 8 inches wide.

The water on entering the inflow gates will swing them open, pass down the downflow shaft at a velocity of 16 feet per second and draw in air through about 1500 half-inch inlet tubes. At the bottom of the shaft the combined air and water will flow in both directions horizontally; the air will separate from the water and accumulate in the upper part of the separating chambers. The water will then flow up the uptake shaft at a velocity of 3 feet per second and out through the outflow gates. The air entrapped in the air chamber is then under a head of water about 195.5 feet high, varying slightly with the hight of the tide. This compressed air is then led up the upflow shaft in a 14-inch pipe. At the top of the gates these 14-inch pipes are united into a 30-inch main which conveys the air ashore.

The air thus compressed will contain about one-sixth the moisture that is in the atmosphere from which the air is drawn, owing to the absorption of the moisture in the compressed air by the surrounding water. This dryness makes it particularly adaptable for transmission in pipes to a considerable distance without undue friction. For instance, the whole 5000 horse-power could be transmitted a distance of 1 mile in a 30-inch pipe with a loss of only 1.5 pounds pressure, or 10 miles in a 48-inch pipe with only a loss of 2.5 pounds pressure. This air can be used cold without danger of freezing in expanding in engines or rock drills. A test was made on an 80 horse-power Corliss engine in which the entering air was at a temperature of 5.3 degrees Fahrenheit and the exhaust at minus 40 degrees Fahrenheit. The engine ran for 10 hours without the slightest sign of frost in the exhaust ports, passages and pipes. A marked economy, however, is obtained by preheating this air immediately before using it in motors, as the pressure rises rapidly with the addition of heat.

There are no working parts in the compressor, therefore little depreciation and operating expense to be taken into account, excepting a watchman to prevent depredations on the plant, keep ice, floating timbers and debris from permanently obstructing the inlet racks and to operate the boat lock. Therefore the cost per horse-power is practically represented by the interest on the original investment and the wages of these watchmen. The cost of original construction will amount to $100 per horse-power.

It is a rather curious fact that, as a rule, in the temperate zones where the population is largest the maximum rise and fall of the tide occurs. This maximum tidal action results in the "wearing out" or excavating by means of tidal abrasion of basins in the coast, usually with a comparatively narrow outlet, conditions which are necessary for an economical development of a tidal air-compressing plant. Each acre of such basin under a 9-foot tide is capable of producing 5 horse-power. It is not commercially feasible to develop such a plant with a basin containing much less than 200 acres, or requiring a length of dam exceeding 3 feet per acre of pondage.

Friction and Lubrication—I

Analysis of Journal Bearing Frictions, Methods of Lubrication and Development of Formula for Coefficient of Friction of Lubrication*

BY DR. J. T. NICOLSON

Engineers who have to spend so much time and thought on the elimination of friction in machinery in order to increase its efficiency, may be expected to look upon it in the light rather of a bugbear which they would be better without. A moment's reflection, however, will show that life without friction is inconceivable!

If all friction were instantaneously removed from the earth it is probable that every living creature would perish in the course of a few minutes. Everything in motion would persist in the same direction with the speed it had till it collided. Everything lying at rest upon a level surface could never begin to move. Wind would have no effect upon the sails of ships, nor would the propeller of a steamer have any power either to start or stop it.

Friction being an inevitable part of our environment, it is well for everyone, and essential for the engineer to know some thing of the laws by which it acts. The present paper does not profess to give much attention to the phenomena of dry friction or the laws of the resistance of one solid moving over another. Its chief aim is to attempt an elucidation of the phenomena of the resistance offered to the relative motion of lubricated surfaces, and in particular of journals and bearings as used in engineering practice.

The experimental results of Stribeck, Dettmar, Heimann, and Lasche, as well as those of Beauchamp Tower, Thurston and others, have been utilized for the purpose of framing rules for the sizing of journals of the different types used in practice. It is believed that the formulas thus obtained give a better approximation to practical requirements of the most divergent kinds than has hitherto been obtained.

In particular, the view commonly held that the length of a bearing should increase in proportion to the speed is shown to be erroneous.

Descriptions of some of the modern methods of automatic and forced lubrication are given. The theory of the action of the loose ring and of the fast collar, as also that of the sizing of bearings for forced lubrication have not been undertaken, the paper being already of sufficient length to exhaust the available space.

Dry Friction

In this case one solid substance rubs upon the other without the intervention of any unguent. The resistance offered to relative motion is then due either to absolute abrasion, or, if this is insensible, to molecular interference between the two surfaces.

However smooth a metallic surface may appear to be to the eye its real condition

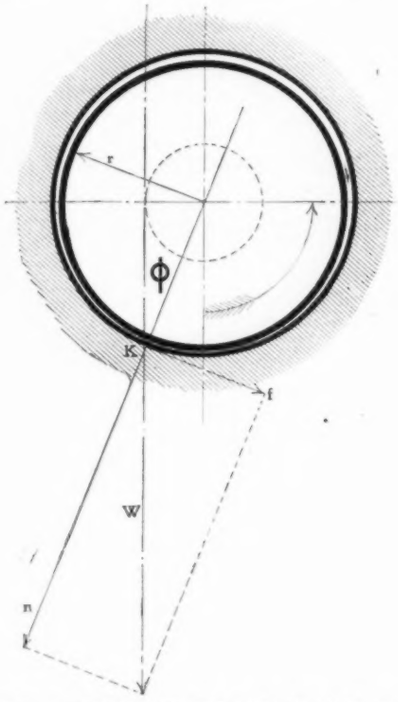


FIG. 1. POSITION OF THE LINE OF CONTACT FOR A ROTATING JOURNAL BEARING

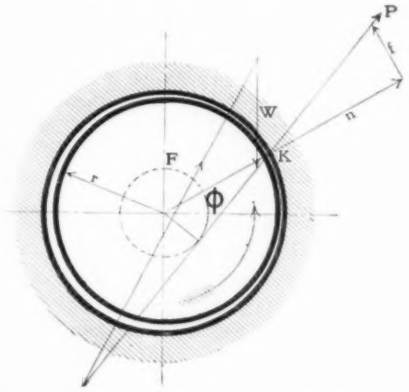


FIG. 2. POSITION OF LINE OF CONTACT IN A JOURNAL BEARING WHEN ACTED UPON BY AN OUTSIDE FORCE

in this respect as it would appear if viewed with a microscope of "double million magnifying power" (to quote Sam Weller) resembles that of a most terrifyingly rugged mountain system.

The peaks and chasms on the two surfaces are crashing into and over each other when there is relative movement. The molecules also are in a state of constant vibration about their mean positions, and even if the mountain peaks be not torn off by the relative movement, the intermingling of the molecules of the two opposing bodies exercises a resisting force by reason of the interchange of their momentum. That such a process should be reducible to any regular system of laws is not to be expected. A complete molecular theory of matter would be required to rationalize the phenomena which occur.

There are certain rough generalizations, however, which are useful to the engineer. Thus:

(1) Within certain small limits the frictional resistance may be said to be roughly proportional to the load acting; or to be independent of the extent of the surface over which that load is distributed; but when the pressure or load per square inch is large the friction increases at a greater rate than the load; or in other words, the coefficient of friction increases with the pressure.

(2) The coefficient of friction varies with the speed of rubbing. It is greatest when the motion is slowest; and when one body is just commencing to move relatively to another we have what has been aptly termed "stiction" or the "friction of repose."

Rennie investigated this point in 1829 and obtained values for the coefficient of "stiction" of from 0.3 to 0.4 for iron upon iron.

For moderate speeds Morin in 1837 found the coefficient of friction to vary from 0.15 to 0.25 for iron upon iron.

For speeds from 10 to 90 feet per second the experiments of Bochet, Poirée and Captain Galton gave coefficients of from 0.2 to 0.1, respectively.

Lastly, for the slowest speeds Ewing and Fleeming Jenkin found that the coefficient of friction of motion merged continuously into the coefficient of friction of repose.

(3) The mutual friction of solids with no unguent interposed was found by Galton to diminish as the temperature increased. This is due to the fact that abrasion is easier at high temperatures. As compared with the internal frictional resistance to relative motion offered by liquids and gases, we find that this diminishes for the liquids and increases for the gases, as the temperature rises. Paradoxical results like these can be satisfactorily explained only by reference to

*Abstract of a paper presented to the Manchester Association of Engineers, Manchester England.

the kinetic theory of liquids and gases, which is beyond our present purpose.

Greasy Friction

When some unguent is placed between the bodies, it may easily be imagined that some of the valleys are leveled up, and the intensity of the molecular action on the mountain tops is diminished. Thus we may have in this case any value up to that for dry friction. For iron upon iron, greasy and polished, Morin obtained the value 0.15 for the coefficient.

In the case of a greasy shaft lying in its bearings at rest, we find that the brass, being somewhat larger in bore than the diameter of the journal, is touched by the latter only along a narrow line at its lowest point. If now rotation begins, the journal rolls up the slope, just like a wheel, until the load on the bearing—supposed vertical—makes an angle equal to the maximum angle of repose ϕ with the journal radius drawn to the point of contact. The point of contact K (see Fig. 1) is then in a plane distant $r \sin. \phi$ from that containing the center of the bearing, and the journal slides on this point, or rather line, with the three forces f, n, and W in equilibrium. The law followed is that of so-called "dry-friction," and the coefficient of friction

$$\mu = tan. \phi = \frac{f}{n}$$

is identical with that found by Morin in 1833 for slightly greasy metallic surfaces, viz., from 0.12 to 0.18—or say 0.15 on the average.* The ratio $\frac{f}{W}$ is, of course, equal to $sin. \phi$, and being nearly the same as $tan. \phi$ for such a small angle—8½ degrees—we have, for the frictional work done per revolution:

$$Friction\ work = \frac{2 \pi r f}{12} = \frac{\pi d \mu W}{12}$$

foot-pounds per revolution.

This is true even when there is plenty of oil, so long as the speed is small.

Take, as an example, the case of a spindle for a 10-inch lathe running slowly with a weight of 3000 pounds carried by the front bearing, which is 3½ inches diameter. Then the friction work per revolution is $0.15 \pi \times 3.5 \times \frac{3000}{12} =$ 413 foot-pounds per revolution.

If the cut were ¼ ×1/16 inch on soft steel, the cutting force would be 3500 pounds, and on a job of faceplate diameter (20 inches) the useful work spent in cutting per revolution would be

$$3500 \times \frac{20 \pi}{12} = 18{,}300\ foot\text{-}pounds.$$

The work lost in friction at the front journal is therefore

$$\frac{413 \times 100}{18{,}300} = 2.26$$

per cent. of the useful work.

*See, *e.g.*, Moseley's "Principles of Engineering," 1843, pages 149-155.

A similar calculation for a lathe of 48-inch centers would show a loss of about 10 per cent.

Such great frictional losses which are constantly and inevitably happening when a lathe spindle, or other rotating shaft, runs slowly, even when abundantly fed with oil, impress upon us the necessity for using measures to preserve a separating film of grease or oil between journal and bearing, and not to allow them to

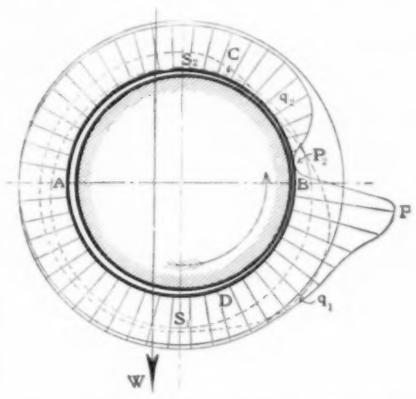


FIG. 3. PRESSURE DISTRIBUTION AROUND A JOURNAL BEARING

run in metallic contact. This is much more difficult to accomplish at slow than at high speeds.

Fig. 2 shows the position of the point or line of contact between shaft and bushing when the force acting has any other position, such as that shown by P. This position may always be found by drawing the resultant force from journal or bearing as a tangent to the friction circle, or radius $r \sin. \phi$, in a sense tending to turn it in the direction of rotation.

Action of a Lubricant at Moderate Speeds

When, as shown in Fig. 1, the load on a journal acts vertical downward and

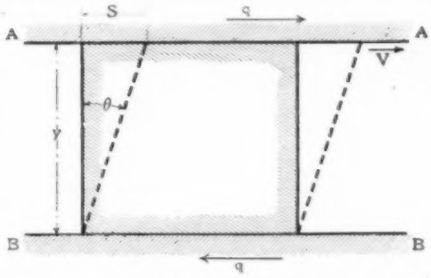


FIG. 4. SHEAR IN A LIQUID FILM

the point of contact is at first at K, Fig. 1, near the bottom, there comes a time as the spindle speed goes on increasing when the oil is carried round with the journal, and forms a film separating it completely from the bushing. The point of nearest approach between journal and brass is by this means shifted round to B, at the back of the bushing, and in the same horizontal plane as the center. See Fig. 3.

The distribution of pressure all round the journal—the interspace all being filled with lubricant—is shown diagrammatically in Fig. 3.

When the speed of rotation is slow the pressure is very great at p_1, just before B, the point of nearest approach, is reached, and falls to nothing at p_2 just after it is passed. It then soon rises and maintains a nearly constant value right round from C through A to D, after which it quickly increases to its maximum.

For greater values of the speed of rotation the maximum value of the oil pressure diminishes, and its position q_1 recedes from the neighborhood of B; while at the same time, the position of the place where the oil pressure is nothing q_2 advances by an equal amount on the other side of B. The point of nearest approach of journal and brass still remains at B, however; but the journal becomes less eccentric. If the speed were infinitely great the journal would run centrally in the brass, and the position of maximum and minimum fluid pressure would be vertically below and above the center, viz., at s_1 and s_2, *i.e.*, in the line of the load. See Fig. 3.

The important physical results depicted qualitatively in Fig. 3 enable us to fix upon the best position in the circumference of the bearing at which the lubricant ought to be applied.

With reference to the familiar instance of the front bearings of a lathe spindle we have, for the two cases of ordinary and forced lubrication, the following rules:

Automatic Lubrication

If the oil is fed in by the ordinary cup and siphon or by a ring or centrifugal method of supply, it should obviously be made to flow on to the journal at the place where the pressure is least; *i.e.*, at p_2, q_2, or s_2, Fig. 3. It will not enter at p_1 or q_1 unless it is under a greater head than that of the oil film at these points.

The oil ways should therefore be fed from a point situated in the top rear quadrant of the bearing when the journal is loaded by gravity only, and the point should be further back the slower the speed. This applies, then, especially to large lathes.

If the loading of the journal is principally due to a cutting force acting upward upon it, the feed should obviously be placed in the bottom front quadrant, and nearer the front the slower the speed of rotation. This meets the case of the smaller sized lathes.

The compromise ordinarily effected to enable the lubricant to enter, whatever may be the direction of the loading, is the simple one of fitting the oil cup on the top of the bearing. This seems almost the only thing to do in the case of automatic lubrication; but it is the correct position only when the resultant force upon the journal, due to gravity and cutting force, etc., acts nearly horizontally and from front to rear.

FORCED LUBRICATION

When the lubricant is supplied by mechanical means at a fixed rate and at any required pressure it must be fed in at the points p_1, q_1 of greatest oil pressure in the bearing. For engine bearings fitted with what is called forced lubrication it is usually fed in at the points p_2, q_2, and s_2. The advantages of the system are not then fully realized.

For large lathes, where gravity is more important, the region of greatest pressure lies in the rear bottom quadrant. For small lathes, on the other hand, in which the force on the spindle acts upward, owing to the cutting force being relatively greater, the maximum oil pressures occur in the front top quadrant.

To meet all contingencies it would appear, on the whole, best in the case of forced lubrication, either to force the oil in at the back of the bearing, well below the center, or, preferably, to fit three alternative branches from the oil-pressure supply pipe to the back, top, and front, any one of which may be turned on at will to suit the conditions of working.

FRICTIONAL RESISTANCE DUE TO VISCOSITY

In describing the phenomena occurring when a journal rotates in a bearing, we have, so far, not alluded to the nature or magnitude of the frictional resistance experienced when there is an abundant supply of lubricant completely separating the former from the latter, and preventing any metal-to-metal contact.

It is frequently stated that "there is no friction without abrasion," or, in other words, that unless two metals rub against each other, there can be no resistance due to relative motion. This, however, is not the case. When a film of lubricant is interposed between two metallic surfaces there is a resistance to relative motion of these surfaces due to the shearing or transverse distortion of the oil film.

In the case of the shearing of a solid, we know that Hooke's law, *ut tensio sic vis*, applies; so that if q, Fig. 4, be the shear stress, and $\frac{s}{y}$ the shear strain, we write $q = G\frac{s}{y}$, where G is the modulus of transverse elasticity. But if the surfaces $A\,A$, $B\,B$ are separated from one another by a liquid of thickness y, and $A\,A$ moves with speed v relatively to $B\,B$, the resistance no longer depends upon the mere magnitude of the angle θ, but upon the rate of its increase with time. If a is the area of either liquid surface, the force required to maintain the steady speed v is

$$F = q\,a = \frac{k\,a\,v}{y},$$

where k is called the coefficient of viscosity of the liquid. (This coefficient is clearly that force which will move a unit area of surface with unit speed relatively to another surface from which it is sepa-

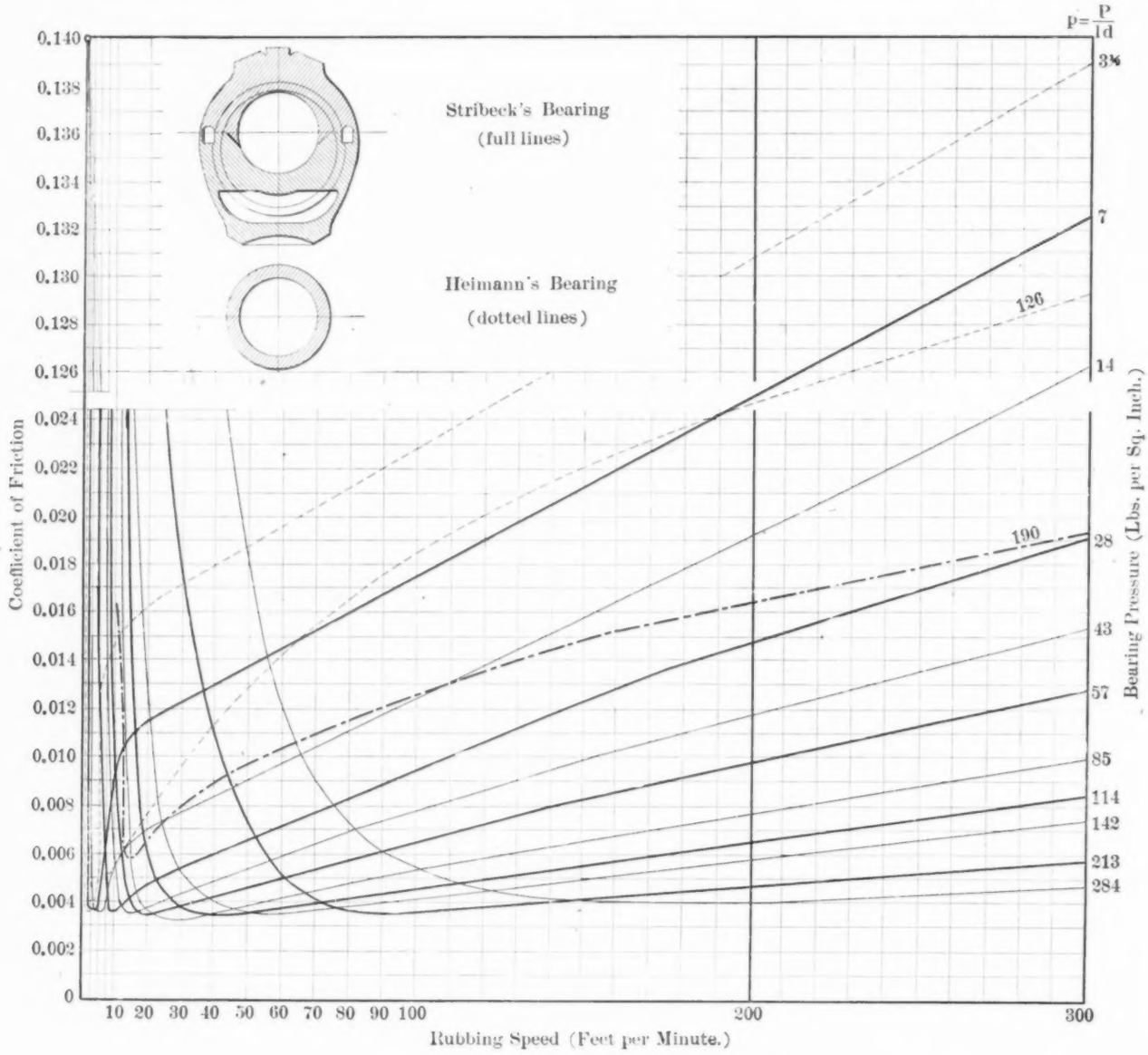


FIG. 5. FRICTIONAL RESISTANCES FOR LOW AND MODERATE SPEEDS

rated by unit thickness of the liquid in question.)

A film of oil of *uniform thickness* y, all round a journal of diameter d and length l, and adhering to it and to the bearing surrounding it, will thus oppose a resistance to the rotation of the former with surface speed v of the amount

$$F = \frac{k \pi d l v}{y}. \qquad (1)$$

In such a case the *friction would not depend on the load*, which does not appear at all in the expression; and it will be readily admitted that the force required to distort the oil film cannot depend on the fluid pressure to which it is, at the moment, subjected. The friction is governed only by the area of viscous fluid to be sheared, and the viscosity of the oil—i.e., the kind of oil and its temperature (with which the viscosity greatly alters)—and it also gets greater the smaller y the thickness of the film; so that if the journal is a close fit within its bushing the resistance to motion will be greater than if the fit is an easy one.

There are, unfortunately, very few cases in engineering practice where a journal rotates with a uniform thickness of oil around it. It is only when the speed is very great indeed that this can happen—as with steam turbines and mill spindles. At moderate and low speeds we know, as above described, that the shaft moves to one side by an amount which depends on the speed and the load; the eccentricity for any given load becoming less the greater the speed. We have just seen that the frictional resistance depends on the thickness of the oil film, but it is known from the researches of Osborne Reynolds, and Sommerfeld that the diminution of frictional resistance, due to the thickening of the film on one side of the shaft, is more than made up for by its increase due to the thinning on the other. On the whole, therefore, the friction gets greater when the journal becomes more eccentric.

Starting therefore with a bearing running slowly, in which the lubricant has just formed a complete film all round the shaft, it will have its maximum amount of eccentricity and the frictional resistance will on this account be large. As the speed is increased, the eccentricity diminishes. The friction should, according to the simple law of oil shearing given above, increase with the speed; but it should diminish on the other hand with the eccentricity. We find, in fact, that at first it diminishes more than it increases, and in this way (the coefficient of friction) attains a minimum value which depends on the circumstances. With further increase of speed the diminution of friction due to the lessening eccentricity becomes insignificant and for a certain interval the simple law of friction is followed whereby the friction increases proportionately to the velocity of rubbing.

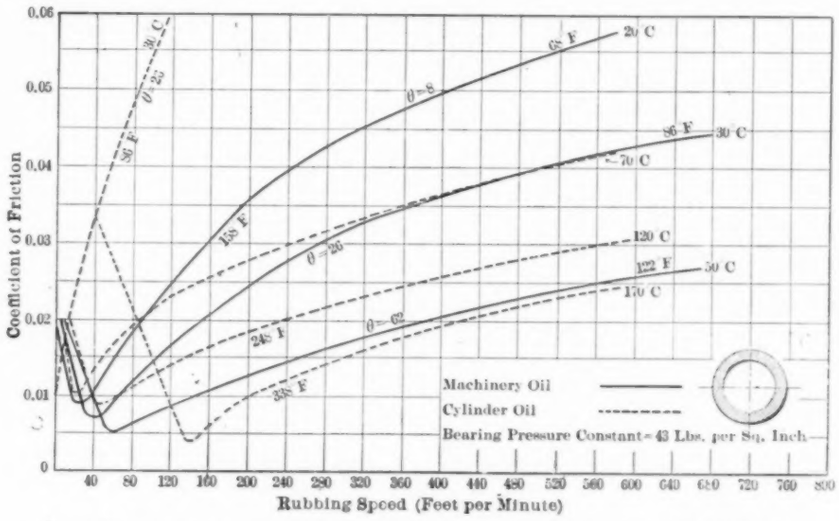


FIG. 6. INFLUENCE OF AN INCREASE OF TEMPERATURE ON THE COEFFICIENT OF JOURNAL BEARING FRICTION

For speeds greater than about from 20 to 80 feet per minute (depending on the kind of bearing) the simple law of fluid friction is interfered with for another reason.

On account of the high speed, the temperature *in the oil film itself* rises above that of the bearing (even when the latter is artificially maintained constant) and its viscosity becomes reduced. The frictional resistance then increases less rapidly than in exact proportion to the speed.

The faster the journal runs, the more the temperature of the oil film rises above that of the bearing, and the thinner or less viscous becomes the oil. For speeds from 50 to 90 up to about 450 feet per minute, the coefficient of friction is proportional to the square root of the speed of rubbing. For speeds between 450 and 800 feet per minute, the friction increases more slowly still, and, according to Thurston, μ varies as $\sqrt[3]{v}$. For speeds of the order of 3600 feet per minute and upward, the influence of speed disappears altogether, and the conclusion arrived at by Lasche is that, for the bearings of high-speed generators driven by steam turbines, whose rubbing speeds are nearly a mile a minute, the coefficient of friction is the same whatever be the speed.

Examples of curves of frictional resistance obtained by experiment for low and moderate speeds are shown in Fig. 5. They are principally those found by Stribeck for experiments with a Sellers bearing having double-ring lubrication, the material being gun-metal.

The two thick dotted curves are taken from Heimann's report on experiments by the method of Dettmar. They refer to a *solid bushing* of gun-metal, with an unbroken film of lubricant all round, which is very different in its method of action from the Sellers or half brass journal experimented on by Stribeck. This accounts for the difference in the shape of the two sets of curves.

The Coefficient of Friction of Lubrication

The curves give the "coefficient of friction" on a base of speed of rubbing in feet per minute. The term "coefficient of friction" denotes the ratio of the total resistance in the bearing due to the shearing of the lubricant, to the load on the journal; and although it has no physical meaning, it supplies a convenient and conventional method of discussing the results.

If F denote the resistance, and P the load, we have

$$\mu = \frac{F}{P} = \frac{k \pi d l v}{P y}, \qquad (2)$$

and if $\frac{P}{d l}$ be, as usual, denoted by p, and called the *bearing pressure*, or load per unit of projected bearing area, we see that

$$\mu = \frac{k \pi}{y} \frac{v}{p} = c \frac{v}{p}, \qquad (3)$$

or the *coefficient* of friction would vary as the speed and inversely as the bearing pressure *if the oil film were of uniform thickness all round, and the temperature of the lubricant were constant.*

Referring to the dotted curves—thick lines—we observe that μ is not proportional to the speed in the actual experiments even when the temperature of the *bearing* is kept constant throughout.

We see that μ increases less rapidly than the velocity of rubbing when the speed is greater than about 20 to 80 feet per minute. This is due to the fact already mentioned that the difference between the actual temperature of the oil film and that of the bearing gets greater as the speed increases, so that although the *bearing* temperature may remain the same throughout a series of experiments, that of the film of lubricant itself, upon which the value

of k—the coefficient of viscosity—depends, does not. Thus μ falls away from the simple linear law the more the greater the rubbing speed becomes.

These—as also Beauchamp Tower's experiments—show that the "coefficient of friction" in a lubricated bearing follows the law

$$\mu = \frac{c\sqrt{v}}{p}$$

$\left(\text{instead of } \mu = c\frac{v}{p}, \text{ as given above}\right)$.

Upon further examination of the experimental results plotted as curves upon Figs. 5 and 6, we observe that for speeds below about 20 feet per minute the coefficient of friction diminishes for a little in exact proportion to the speed, but that the effect of the relatively great eccentricity of the journal in the bushing soon begins to have an important influence in increasing the friction; so that after a while the curves of μ take reverse turns, and the coefficient attains a minimum value as described above.

As to the positions of the minimum points, we see that the coefficient of friction takes its least value for speeds which depend upon the bearing pressure; those speeds being greater the greater the bearing pressures—Fig. 5.

After the minimum points are passed the curves begin to rise more or less rapidly as the speed continues to fall. This is due to the oil film being squeezed out of the bearing; and we shall find it necessary to attach great importance in the sequel to this so-called "minimum point," as bearings must be designed so as to avoid such speeds and pressures as correspond to them.

In Fig. 6, reproduced from Heimann's article, we observe the effect on the coefficient of friction and on the positions of its minimum points, of an increase of the temperature of the bearing. The higher the temperatures at which the bearing runs the smaller the coefficient of friction, and the greater are the speeds at which the minimum values of that coefficient are attained.

In conclusion, we observe that the curves all rise very rapidly when the speed is very slow and the oil has all been squeezed out of the bearing; and that they tend to converge upon the constant value 0.15, the coefficient of friction for greasy metals sliding upon each other, long ago determined by Morin. It is only then that μ remains constant, and that we encounter a frictional resistance and loss of work proportional to the load on the bearing and of the amount already calculated.

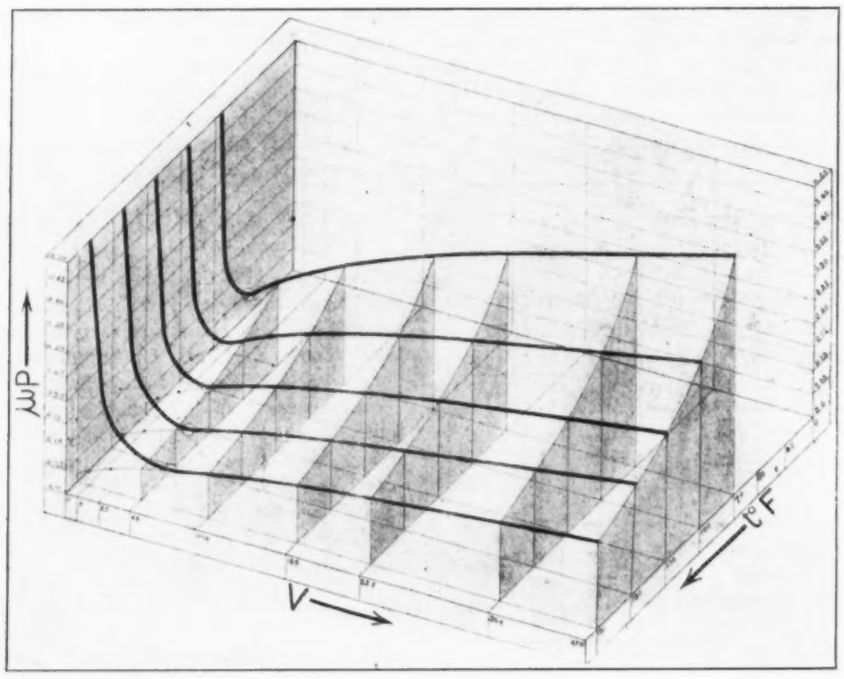


FIG. 7. FRICTIONAL RESISTANCE OF ROTATING LUBRICATED JOURNAL BEARINGS

Formula for Coefficient of Friction

Reverting to the theoretical law of fluid mentioned above,

$$\mu = \frac{c\,k}{y}\,\frac{v^n}{p},$$

we find that experiments show that n has values diminishing from ½ to 0 as the speeds increase from 100 to 3600 feet per minute.

Clearly, the variation should be made in the value of k, the viscosity coefficient and not in that of v; for the law of shearing resistance is equally $\frac{k\,v}{y}$ at high as at low temperatures.

If we could calculate the excess of mean temperature of the oil film over that of the metal walls between which it is flowing, then knowing how k depends upon that (mean) temperature we could predict the proper form of the expression for any given case.

The author has found a simple expression which gives the values of k with fair correctness between the temperatures 70 degrees and 160 degrees Fahrenheit; the more correct expression of Osborne Reynolds being—$k = 0.000047\, e^{-0.0221\,t}$.

The formula is

$$k = \frac{B}{(t - 60°)}, \text{ or } k = \frac{B}{\theta},$$

where B has the value $\frac{1}{500}$.

Thus we write

$$k = \frac{1}{500\,\theta}. \qquad (4)$$

A roughly accurate expression for the coefficient of friction for machinery oil as deduced from these experiments will therefore be for speeds over 20 feet per minute.

$$\mu = \frac{c\sqrt{v}}{\theta\,p}. \qquad (5)$$

$$\mu = \frac{900\sqrt{v}}{500\,\theta\,p} = \frac{1.8\sqrt{v}}{\theta\,p}. \qquad (6)$$

Here v = surface speed in feet per minute,
p = bearing pressure in pounds per square inch,
and θ = excess of oil temperature above 60 degrees Fahrenheit.

This may be written in the form:

$$M = \mu\,p = \frac{1.8\sqrt{v}}{\theta}, \qquad (7)$$

where M may be called the specific friction. It is the frictional resistance per square inch of projected bearing surface. Its values are given in Fig. 7.

France also has its train robbery, with the latest modern improvement, namely, an automobile to escape on. The robbers took a first-class compartment made their way on the foot-board of the cars to the baggage car, in which two mail agents had charge of money packages, wounded both of them with pistol shots, and threw out the money packages. The wounded agents succeeded in pulling the cord which signalled the engineman to stop; but when the train slowed down the robbers jumped out. Accomplices had picked up the money and followed the train on an automobile, the track there being alongside the highway, and it picked up the men when they left the train and rushed away without observing the legal speed limit.—*Railroad Gazette.*

Novel Electric Drive for Rolling Mills

Making a Small Motor Drive the Rolls during the Passes by Utilizing the Stored Energy of a Heavy Fly-wheel

EDITORIAL CORRESPONDENCE

In no instance is the advantage of using a fly-wheel to store energy for future use more clearly shown than in the new motor-driven 30-inch universal plate mill of the Illinois Steel Company at South Chicago, recently installed by the Westinghouse Electric and Manufacturing Company. It is the first application of electric motors to this work, and the units are the largest that have ever been used.

The first step toward the solution of the problem was to find out the amount of power required for this service, as practically no data were available on this subject, the usual solution being to install a motor of the maximum torque equal to that of the steam engine that would have been selected but leaving the normal capacity of the machine very much in doubt.

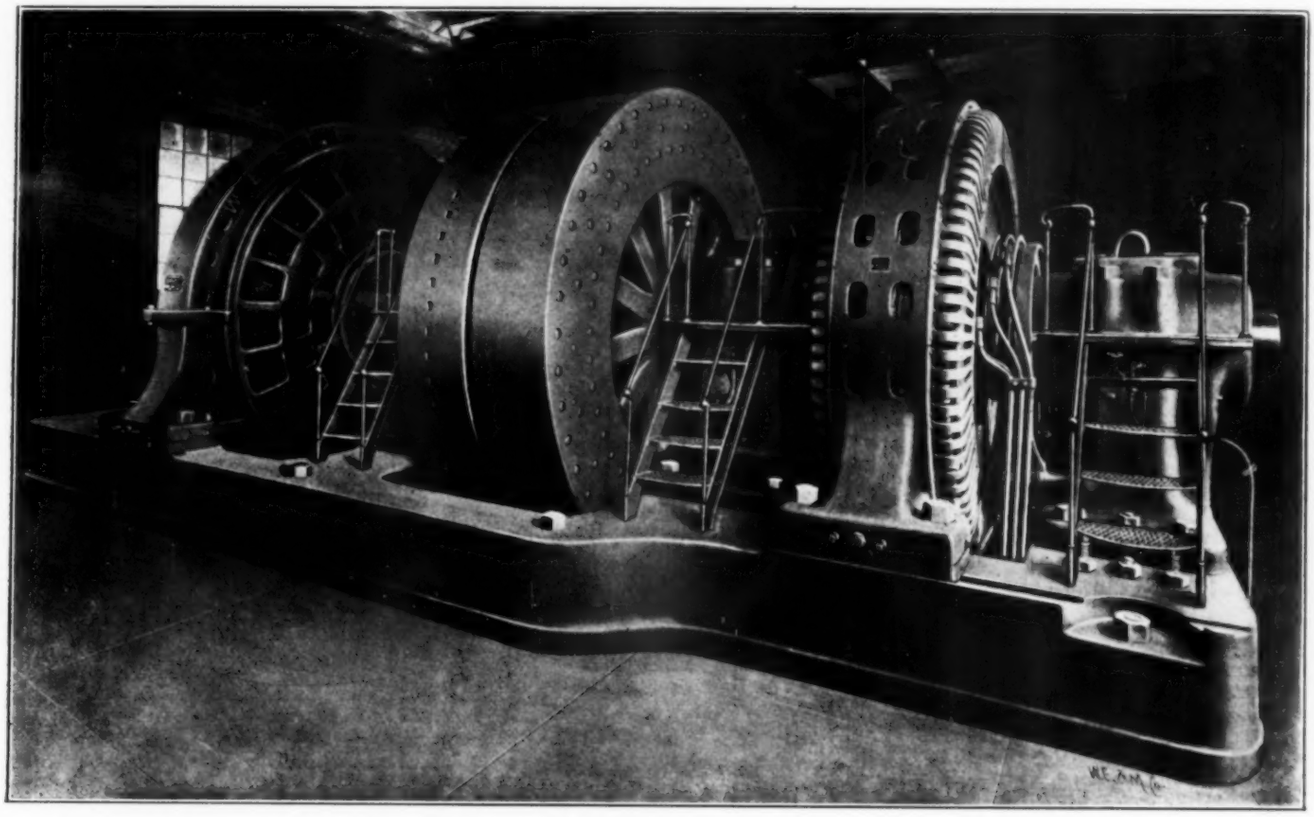


FIG. I. THE EQUALIZING SET WHICH SUPPLIES CURRENT TO THE MILL MOTORS

Many experiments were made, beginning with a non-reversing mill, by carefully indicating the engine, noting the fly-wheel speeds, the nature of the material being worked and the dimensions of sectional area affected, so that the average horse-power required for the reduction of a given weight of material might be determined. Using these data as a basis, the next observations were with the reversing type of mill, which is much more complicated in every way owing to the largely increased size of motors required and the fact that the application of fly-wheel direct to the roll shaft and the operation of the motor direct from the power station are not practical on account of the rapid acceleration, retardation and the reversal of the rolls. Figured in the usual way, it would have been necessary to install apparatus capable of supplying a maximum demand of 10,000 horse-power, and the regulation would be a very serious consideration.

To make electrical driving feasible it is necessary to equalize the power requirements from the central station; this has been done by the plan worked out in this case in connection with a high-voltage alternating current, owing to its advantages in transmission over the direct current.

The investigations of the power required for reversing rolling-mill work included continuous indicator diagrams and a careful study of speed variations; the movement of inertia of the system and its kinetic energy at any given speed were calculated and the power required for acceleration determined. From these data a curve was plotted showing the torque actually required at the surface of the roll for the various passes or for a given reduction of sectional area. Corrections to allow for the increased power required during the last passes, owing to the metal being cooler, were also made; but these are less than might be supposed, owing to the smaller reduction of area at each pass than in the breaking-down passes when the metal is hotter.

Some of the facts brought out are extremely interesting, and it is somewhat startling to learn that the acceleration from zero to full speed takes place in from two to five seconds; the material enters the rolls when they are at approximately half speed; current can be shut off from the motor and the rolling continued by the energy of the moving parts, so that the material leaves the rolls at half speed; the interval of time for handling the material between passes varies from two to three seconds.

The speed increases between the first and the last pass while the torque de-

creases, so that the actual power requirement is fairly uniform from start to finish.

The number of passes required to roll the average plate is 13 and the time for one cycle is 75 seconds. This is divided into a working period of 48 seconds and a total interval of rest equal to 27 seconds, with an approximate period of 2 seconds between passes.

The horse-power required varies from zero to 3400, which gives an average for the cycle of 1170 horse-power.

In the case of the 30-inch mill equipment the various problems have been solved by supplying a direct-current shunt-wound motor for driving the mill and using an equalizer in the form of a fly-wheel type motor-generator set, located in the electric circuit between the mill motor and the central station which supplies high-voltage alternating-current power. The equalizer set operates continuously with relatively slight variation in speed. The field of the mill motor is permanent while that of the shunt-wound motor is variable. With zero current in the generator fields the electromotive force of the armature circuit is zero and no current is supplied to the mill motor, the armature of which is connected permanently by heavy leads to the armature of the generator.

Current is applied to the generator fields first through very high resistance; as this is cut out, the field is strengthened and the generator voltage is increased accordingly. The motor speed follows the variation directly and the amount of current which it takes will be governed by the torque required to perform the work. The reversing of the mill motor is accomplished by reversing the current in the generator-field circuit, which changes the direction of flow of current in the armature circuit of both the generator and motor. Thus the full control of the mill motor is obtained by means of a field rheostat which governs a circuit of less than 150 amperes.

The function of the fly-wheel is to convert this varying load into a uniform constant load; consequently the required capacity of the alternating-current motor of the equalizer set (and the power taken from the line) is designated by the average load condition. The three factors to be considered in figuring fly-wheel capacity are the amount of energy required from the fly-wheel, which is usually figured in horse-power seconds, the percentage drop in speed allowed and the time available for storing up energy in the wheel. The drop in speed of the motor-generator set ranges from 10 to 15 per cent. for the heaviest passes; and, in case the loads should be greater than that calculated, a further drop in speed is obtained automatically.

Equalizer Set

This set is shown in Fig. 1 and is of the four-bearing type and consists of an alternating-current induction motor, a direct-current generator and a fly-wheel located between these machines, all mounted on a common shaft and on a common bed plate.

The alternating-current motor has a continuous-load rating of 1300 horse-power and will develop a maximum torque three times the full-load torque. It is 25-cycle, 2200-volt, 8-pole, with a synchronous speed of 375 revolutions per minute. No transformers are needed, as the voltage of the motor primary is the same as that of the feeder circuit.

FIG. 2. ONE OF THE FLY-WHEELS

The fly-wheel is shown in Fig. 2, for reasons of manufacture and in order to keep the diameter as small as possible, it is made in two sections. Even with this arrangement, however, the peripheral speed which is 250 feet per second, or nearly 3 miles a minute, is hardly within a safe limit for a cast-steel wheel, so a laminated type was decided upon. The total weight is 200,000 pounds, the diameter is 13 feet 2 inches, the radius of gyration is 5 feet 2½ inches, and the fly-wheel effect is 2,660,000 pounds at 1-foot radius.

The wheel is made up of a sheet-steel rim and a cast-steel spider with double spokes of comparatively small sections, for the purpose of making the wheel more elastic than a single spoke of equal strength. The frame of the spider is machined with dovetail slots and the thin steel sheets are punched in segments with tongues to fit into the spider rim slots. These segments are assembled with overlapping joints; on the outside are heavy one-piece steel end rings, clamped to the laminations by means of through bolts. In reality very little strain comes on these bolts, as the thin sheet construction gives a very high slipping resistance with a comparatively light pressure.

To give an idea of the energy stored in this wheel and the efficiency of the motor-generator set, it requires 1200 kilowatts for a period of five minutes to accelerate it to full speed, and the load, running light, is 200 kilowatts.

The direct-current generator has a continuous rating of 3000 kilowatts or 4021.4 horse-power at 600 volts, 375 revolutions per minute, and will stand 150 per cent. overload without injurious sparking.

Mill Motor

The direct-current mill motor will safely carry a continuous load of 4000 horse-power at 575 volts, 150 revolutions per minute, and will stand a maximum of 10,000 horse-power momentarily. As shown in Fig. 3, it consists of two 2000 horse-power units with the armatures mounted on the same shaft and with both motors arranged on a common bed plate, forming a two-bearing set. The principal reason for the subdivision is to reduce the fly-wheel effect by using armatures of small diameters. The power required for acceleration is thereby reduced, facilitating rapid reversing.

The normal speed of the motor is 100 revolutions per minute, and the higher speeds are obtained by means of shunt-field control. It will be noted that thus far the maximum speed desired has been approximately 80 revolutions per minute, most of the product being of a comparatively heavy gage. But as operation is carried on, the efficiency of the mill will gradually be increased and the higher speeds thus available will be the means of greatly increasing the output.

The motor is connected to the mill by means of a flanged coupling, and the bearing next to the mill is exceptionally large and well reinforced. It is specially designed to withstand the heavy end thrust

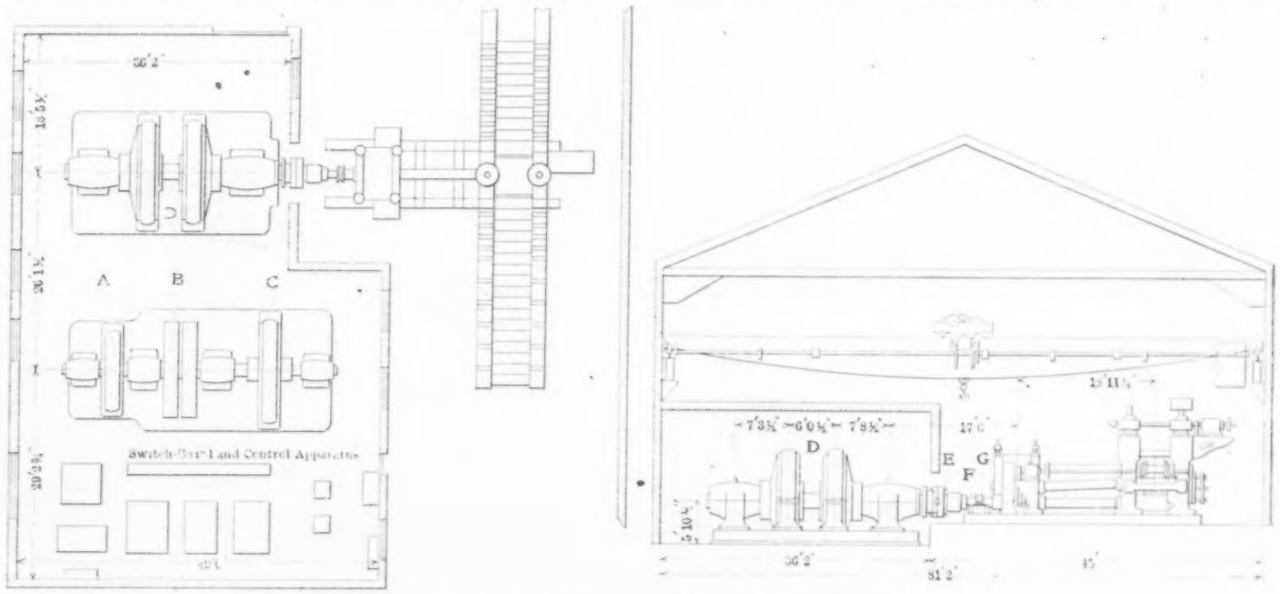


FIG. 4. GENERAL ARRANGEMENT OF MILL AND MOTORS

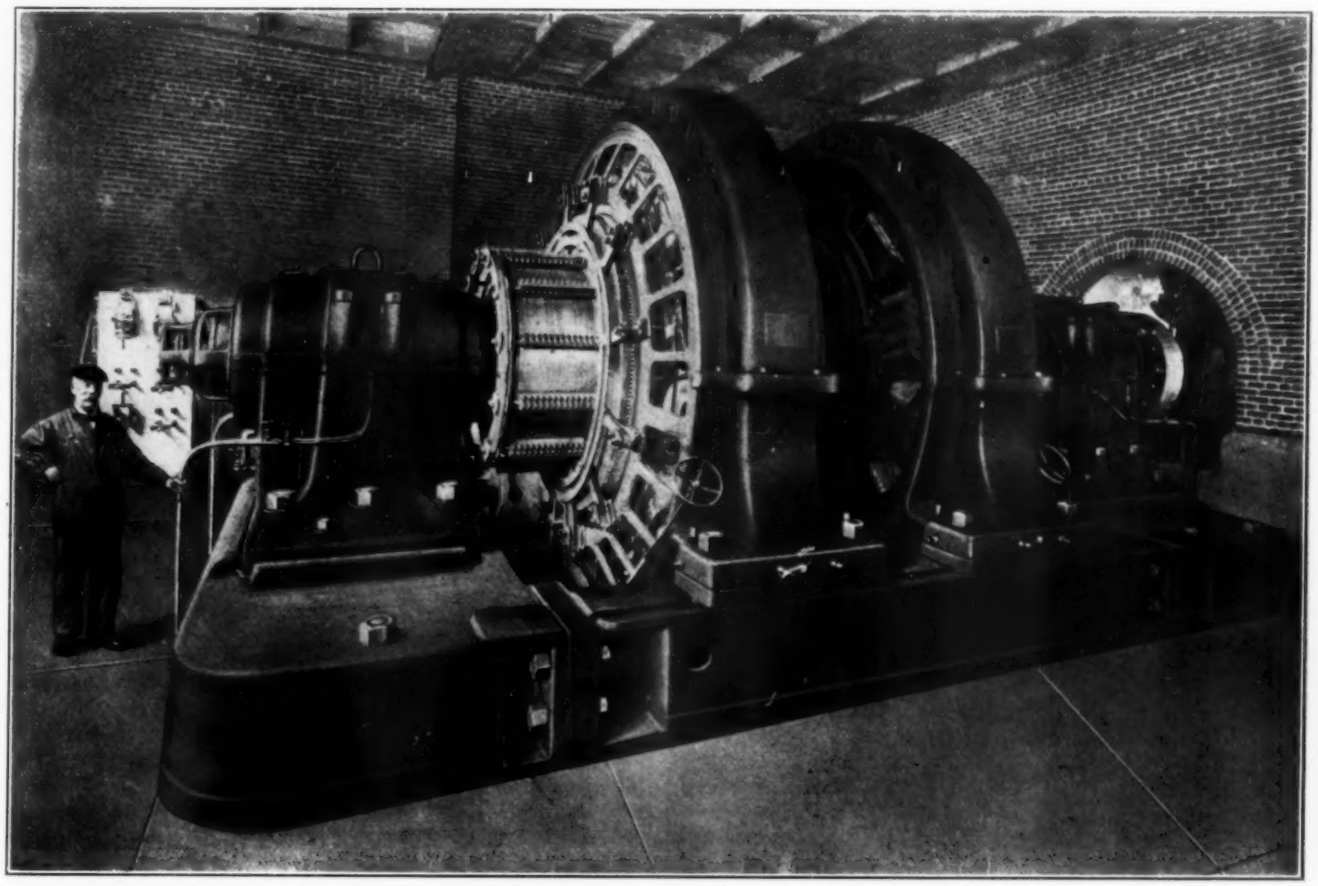


FIG. 3. THE MILL MOTOR AND ITS CONNECTION TO THE ROLLS

that occurs when the mill spindle breaks on a diagonal, thereby tending to lengthen itself between bearings. To provide for the ordinary thrust of the mill, a semi-circular babbitt-faced collar is bolted to the outside surface of the mill and bearing. A babbitt-faced collar provided with adjusting bolts is keyed to the ends of the flange coupling next to the bearing, and this acts as the shaft wearing collar. It is split so as to allow easy replacement or repairs. This figure shows the removable portions of roof, so crane outside can handle the machinery in the motor house.

The general conditions for rolling a 10x¾-inch universal plate 65 feet long from a 6x10-inch slab 8 feet long, were as follows: The average alternating-current power required was 750 kilowatts with 15 per cent. variation above and below this amount, and the total peak loads on the direct-current machines ranged from 4000 to 5000 amperes. The average time required to roll one plate was two minutes, giving the plate fifteen passes. The maximum capacity is 6 to 30 inches wide by 80 feet long and will handle 7500 tons a month.

Referring to Fig. 4, the equalizer set is comprised of an alternating-current motor *A*, 1300 horse-power, the fly-wheel *B*, weighing 100 tons, and the direct-current generator *C*, nominally 4021 horse-power, but capable of 10,000 horse-power. The direct-current motor *D*, also 4000 to 10,000 horse-power, is connected by a flange coupling *E* to the driving spindle *F*, which drives the pinion shaft *G*, by means of loose box couplings or muffs and a short piece of shaft or wabbler. The pinions are mounted in a suitable housing and each pinion shaft is connected through muffs or wabblers to a horizontal roll. A pinion which meshes into the upper roll pinion drives two horizontal shafts which extend to the outside of the mill housing. These shafts carry the bevel pinions which drive the vertical rolls—two of which are located on each side of the horizontal rolls.

Current from the power house comes to the motor *A*, which drives generator *C*. This in turn supplies current to the mill motors *D*, which can handle the normal load with the current due to the 1300 horse-power motor *A*. The rapidly running fly-wheel stores up energy so that when the peak of the load comes it drives generator *C*, up to an output of 10,000 horse-power for the moment, if necessary, which in turn supplies this amount of current to the motor *D*, long enough to take care of the pass in the rolls. In this way a small motor is made to handle the work that would ordinarily require a much larger unit and is a very striking example of fly-wheel energy as well as of the flexibility of the electric drive. The possibility of securing a speed variation as high as three to one without the use of gears is also a large item in this class of work.

Portable German and English Electric Drills on Trucks

By Frank C. Perkins

Every form of labor-saving device is now being used which will increase the output of the machine shop or boiler plant, or save time by doing away with the necessity of moving large work which is under construction. The portable electric drill is among these devices, and it is frequently mounted on a small truck for moving about the shop and around the large work requiring its use. The accompanying illustration, Fig. 1, shows such a portable electric drilling machine of German design, made by Siemens-Schuckert-Werke, of Berlin. The motor is provided with a flexible electric cable and is mounted on wheels. It has inclosed gearing for transmitting the power from the armature shaft to the drill shaft, and universal joints connect this shaft with the drill head. In general, direct-current motors are used of 110 or 500 volts pressure, yet in some instances alternating-current motors of single-phase, two-phase and three-phase induction types are employed.

Flexible shafting is sometimes employed in place of the jointed shaft, as in Fig. 2. This is an English high-speed portable drill of the "Stellite" type, equipped with a magnetic clamp. This equipment was designed and constructed at Birmingham, England, by the Electric and Ordnance Accessories Company, Ltd. It has variable speeds, and a capacity up to a 2½-inch boring bar. The flexible shafting has ball bearings, and knuckle joints are used to transmit the power from the motor armature shafts to the drill head, in addition to the flexible shaft. A special water-tight starter is fixed on top of

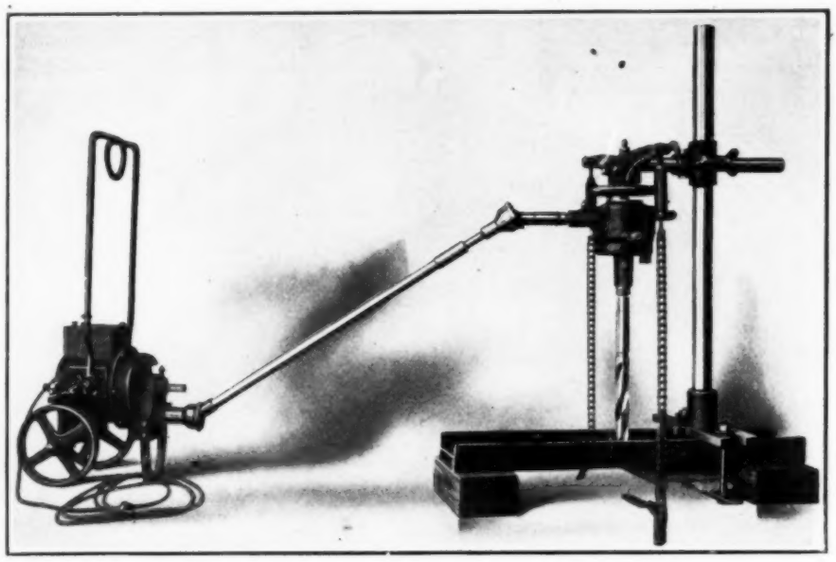


FIG. 1. A GERMAN PORTABLE ELECTRIC DRILL

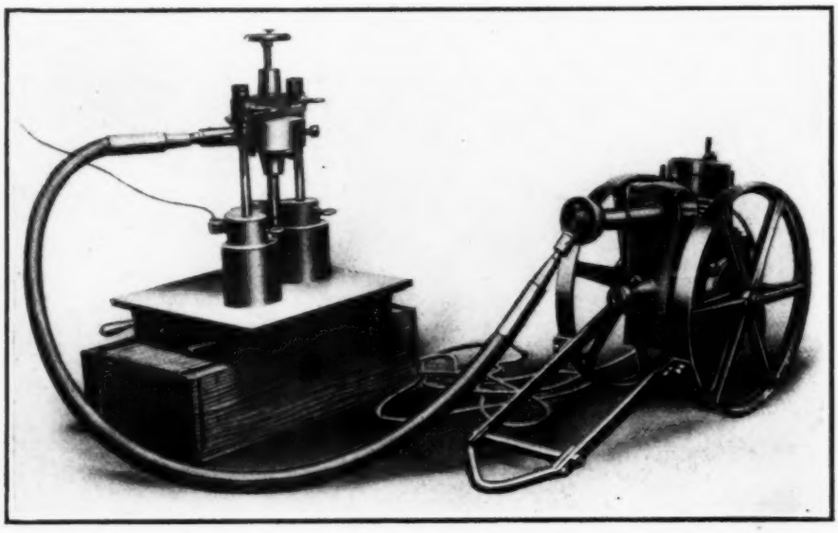


FIG. 2. AN ENGLISH PORTABLE DRILL

the electric drill motor and about 15 feet of cable are utilized, inclosed in flexible steel tubing. It will be noted, in Fig. 3, that the electric motor is inclosed in an oil-tight cast-iron box and runs practically without noise. The speeds are arranged to suit high-speed twist drills, and the variation of the drilling speed is obtained automatically by compound winding of the motor and by changing the feed pressure. It is maintained that these portable electric drills are not only simple but economical, and they are claimed to be from 30 to 50 per cent. more efficient than pneumatic drills. By the use of magnets with pillars with the drill head, the equipment is firmly held to iron or steel plates and the drilling is accomplished with facility.

Another interesting portable electric drilling machine is constructed at Bootle, near Liverpool, England, by Campbell and Isherwood. It can be used on boilers or steel plates in shipbuilding and may be taken from the truck on which it is mounted, for moving about the shop, or may be suspended in any desirable position. It is shown in the accompanying illustrations Figs. 4 and 5, and comprises a motor, carriage and sliding shaft with a universal-movement drill head. The motor is series wound. It will be noted that it is mounted on two horizontal centers by a frame which may be moved in a complete circle, the whole being carried on a carriage provided with wheels, to permit of easy movement. When desired, the motor may be removed from the carriage and suspended from a stirrup, see Fig. 5. A bracket on top of the motor carries a hollow shaft fitted at one end with a spur-gear wheel which is driven from a pinion on the armature shaft. Through this hollow shaft runs a long shaft, one end of which is connected to the drill head. The long sliding shaft is slotted for nearly its whole length, and this fits a feather key on the inside of the hollow shaft. In this manner the motor drives the hollow shaft; by means of the key and slot the motion is transmitted to the drill head. The gearing is entirely covered, thus protecting the workman against accident, while all of the electric terminals are carefully insulated.

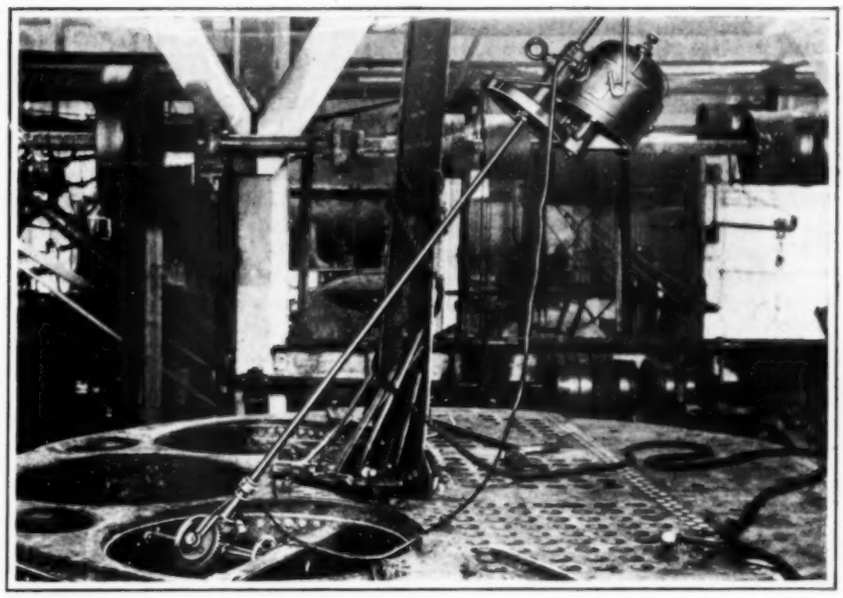


FIG. 5. AN ENGLISH DRILL SUSPENDED TO PERFORM A DIFFICULT OPERATION

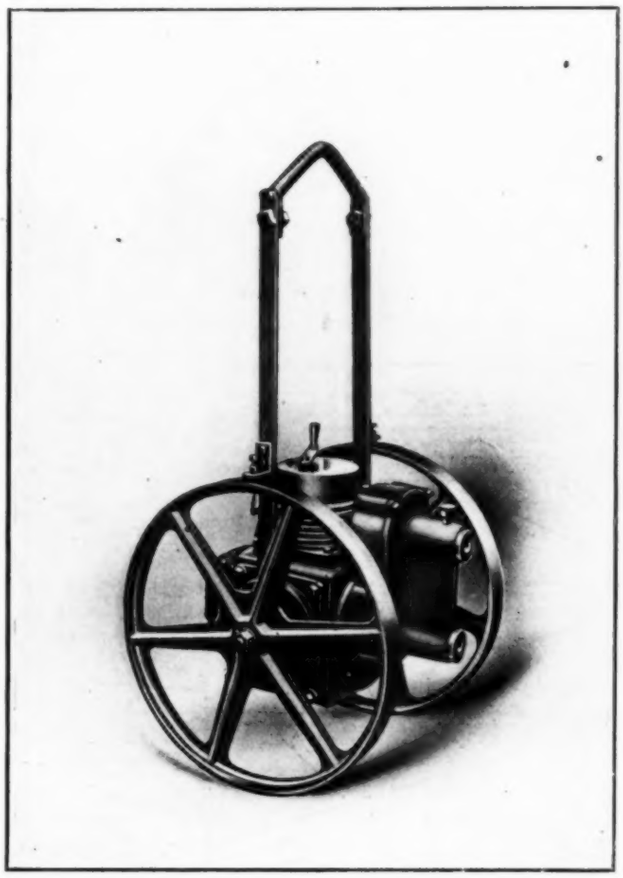


FIG. 3. MOTOR OF DRILL SHOWN IN FIG. 2

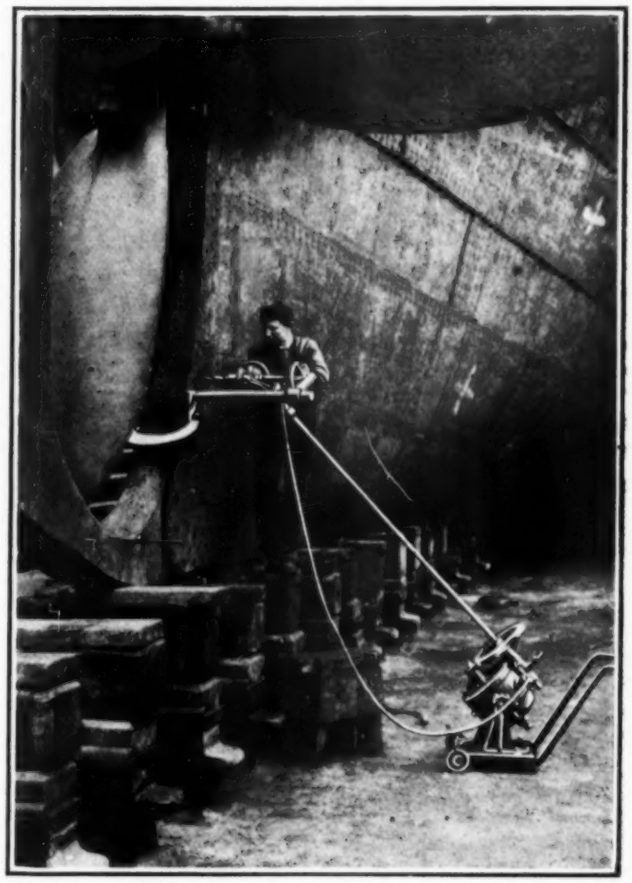


FIG. 4. ANOTHER ENGLISH PORTABLE ELECTRIC DRILL

An Interesting Boiler-riveter Installation

In connection with a boiler shop everybody today appreciates the advantage and necessity of a large riveting machine. It is not always convenient, however, nor is it always a warranted expense to install a vertically set riveter with its tower and building equipment, crane and runway, electrical and other apparatus. The following method has been worked out and built by the Chester B. Albree Iron Works Company, of Allegheny, Penn. Two installations are in service at present, the New York Safety Steam Power Company, at Hope Valley, R. I., and the Tennessee Coal, Iron and Railway Company, Ensley, Ala., and others are under way.

The drawing shows a 10-foot 6-inch gap riveter, weighing 22,000 pounds, suspended from a trestle work, with a specially built truck on which the work is pushed into the riveter. A sprocket wheel is provided which is turned by means of a pipe or crowbar and pinches the work back and forth. This sprocket wheel can be located, as shown, on the end of the truck, or it can be made stationary on the foundation near the operator or wherever convenient. The riveter is raised or lowered by a small pulley block, as it is perfectly counterbalanced with nothing but friction to overcome. It will be noticed that small wheels and ball-bearing journals are provided on the truck, which allow the pipe or boiler to be rotated. If square work is to be done, a plate is put on the top of these wheels and the work rested on the plate, which allows a transverse as well as a longitudinal movement of the work.

The cost of such an installation is about one-quarter that of a hydraulic riveter with high-pressure pumps, lines, valves, accumulators, usual steel tower, crane, runway, etc. The cost is also about one-half that of installing the usual stationary pneumatic compression riveter where the riveter is placed vertically. The following figures may be of interest in this connection:

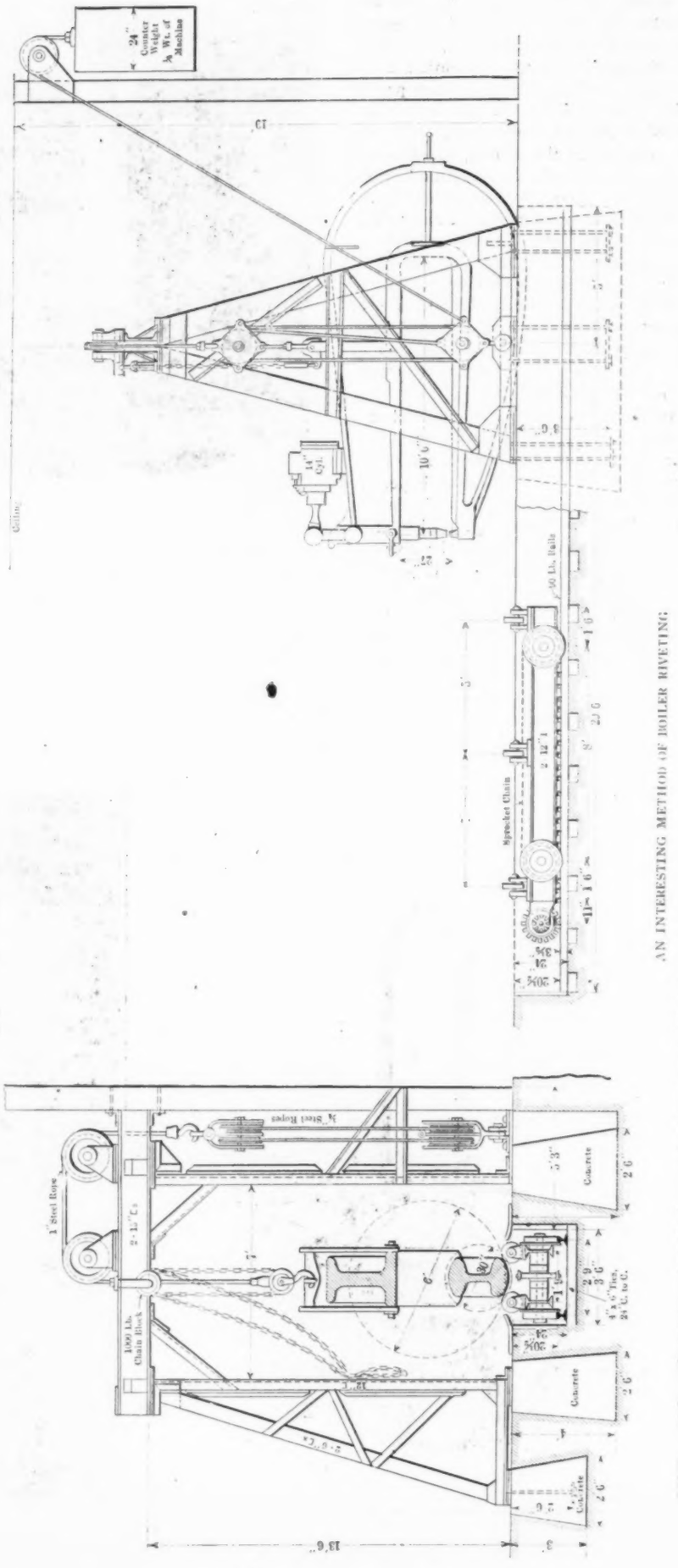
COST OF A HORIZONTAL PNEUMATIC INSTALLATION.

Compression riveter, 10-foot 6-inch reach	$1900
Support, trestle, truck, etc.	1000
Foundation, erection, miscellaneous	400
Air compressor and reservoir	600
	$3900

THE SAME RIVETER SET VERTICALLY WITH CRANE, STEEL TOWER, ETC.

40-foot tower, 25-foot runaway, 16-foot span	$1500
Crane and hoist	1800
Dynamo and switchboard	800
Compression riveter, 10-foot 6-inch reach	1900
Air compressor and reservoir	600
Foundation and building changes	900
	$7500

Such a method of installing might be applied to a hydraulic machine, but on account of being obliged to provide flexible



AN INTERESTING METHOD OF BOILER RIVETING

high-pressure water pipes an air machine is preferable. The power used in operating the air machine is about one-quarter that for the hydraulic on account of the air machine having a toggle leverage which gives the maximum pressure at the end of the stroke only; whereas, in the hydraulic machine, the high pressure is continuous throughout the stroke. This is quite a saving, as it probably costs $800 to $1000 per year to run a hydraulic machine and there is $300 or $400 saving in favor of the air installation.

Very satisfactory results are being obtained from these installations, and anybody contemplating the installation of a riveter would do well to visit one of these plants.

The London *Times* says that the work of pioneers in color photography has reached a promising stage and that a plate is now on sale upon which a fairly satisfactory heliochrome transparency may be made with one exposure, and with little more trouble than when making an ordinary negative.

Hardening Small Pieces

By Nene

The following is a description and drawing of a device for the hardening of small pieces such as are shown by Fig. 3, or in fact any kind of small pieces. The principles involved have been discussed previously in the columns of the American Machinist, but the excellent results obtained by the application of these principles are, I consider, worthy of mention.

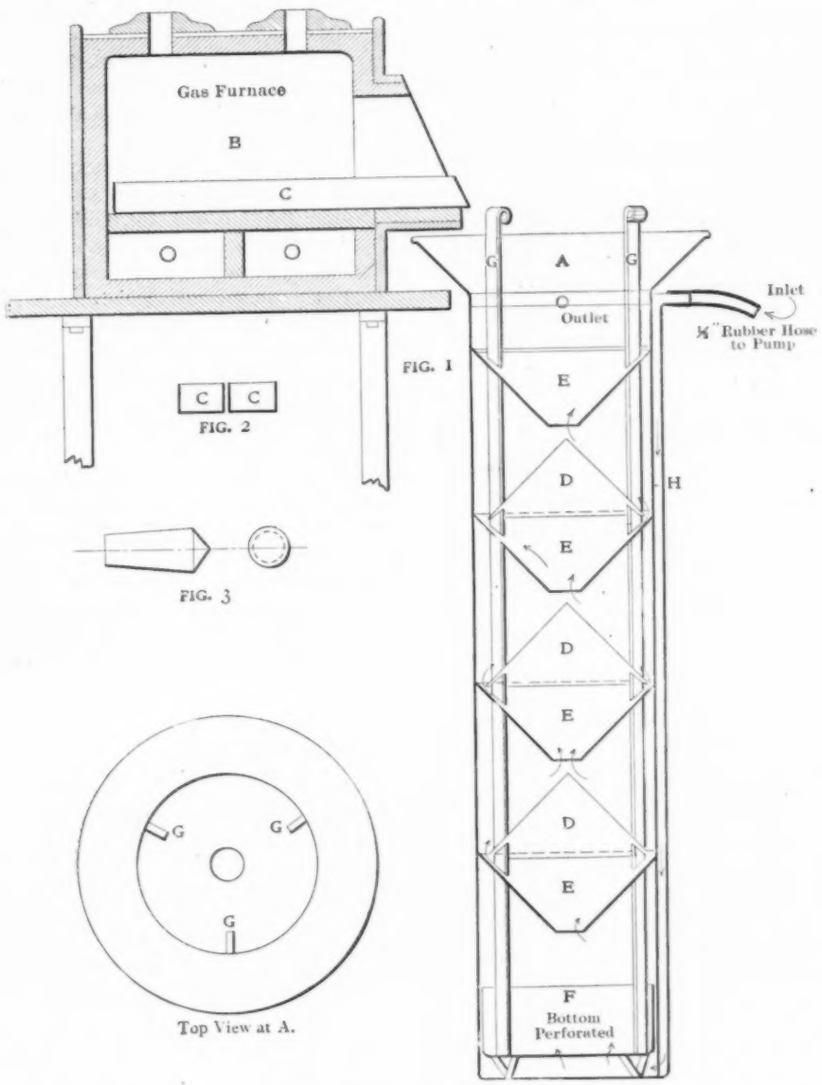


FIG. 1

FIG. 2

FIG. 3

STEEL HARDENING APPARATUS

The simple fact that some one has received good results from applying these principles encourages others to try methods of this sort, as in hardening a large lot of small pieces much variation is liable to occur unless some means of quenching them quickly, thoroughly and evenly is provided.

Previous to making this device, we used a tall tank similar to *A*, without the cones *D* and *E*. The result necessitated the file testing of every piece before using. This was entirely eliminated after making this device, and there have been no soft pieces since installing it. By adding the cones, the pieces to be hardened slowly settled to the bottom in an irregular line and were cooled before landing on the bottom; this prevented a zone of heat being established there which would have happened if they had sunk in a straight line. Then again the liquid was kept circulating by being pumped in at the inlet, flowing through the perforated bottom at *F* and out at the outlet. In this way it is kept at an even temperature and not allowed to become too hot to quench the pieces evenly and thoroughly, through heat being imparted to it by the hot metal as it is dumped in.

Referring to the drawing *A*, Fig. 1 is a tank of galvanized iron about 9 inches diameter and 40 inches high (the hight being regulated by the door of the furnace). The cones *D* and *E* and the pan *F* are built on three upright pieces of heavy band iron, as shown at *G*, which slide easily inside of the tank *A*. The cones *D* and *E* are made of the same material as the tank *A* and are beveled about 45 degrees; in no case have the pieces stuck part way down. The quenching brine is forced in at the inlet by a bronze circulating pump and is carried to the bottom of the tank by the pipe *H*, following a course shown by the arrows. It is forced up through the bottom of pan *F*, which is perforated, then through the openings in the cones; it overflows at the outlet back into a large tank, used for general hardening. *C*, Fig. 1, is a double trough of cast iron, as shown at Fig. 2, while *B*, Fig. 1, is an ordinary gas furnace made by the American Gas Furnace Co.

In the operation a shovelful of the pieces to be hardened is placed in one side of the trough *C*. After a few minutes a similar amount is placed in the other side of the trough; the first lot is raked out, by means of a bent poker, into the tank and replaced by a new lot, by which time the second shovelful will be heated and ready to receive the operator's attention. After 15 or 20 pounds have been treated in this manner, the cones and pans are lifted out and the contents removed.

The tank may be emptied of liquids by simply reversing the belt of the pump, after which the tank may be placed out of the way until it is required again.

Consul Alfred A. Winslow, of Valparaiso, writes that there is a good opening in Chile for American machinery, but it must be pushed. He writes: I doubt if it would pay well here to start in a small way. One should be in shape to make a good showing and be able to establish confidence, and that would require considerable capital. The language of the country is Spanish, though there is much English and German spoken. American goods and machinery stand well here, but are not as well known as those produced in England and Germany. We should have the business.

Practical Letters From Our Readers

A Round Table Discussing Details of Modern Machine-shop and Drawing-office Methods, Practice and Economy

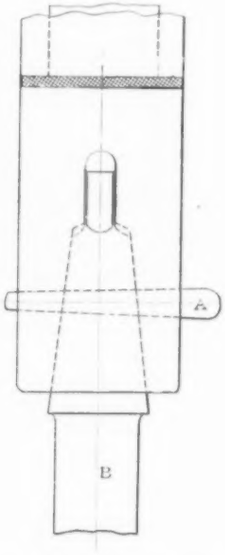
WE PAY FOR USEFUL IDEAS

A Suggestion in Connection with the Spindle of the Drill Press

When will the leading drilling-machine builders of America and England fit a taper hole in drill-press spindles, as shown in the accompanying sketch? The expense incurred is only trifling, and the utility of the drill is extended; even if the hole is never used, it is no detriment.

Of course, in the ordinary run of drilling, this hole is never required; but when you commence to face the under side of bolt holes on pipe flanges, brackets for machine tools, etc., you see some fun.

The cutter bar shown at *B*, having no fastening at the top, drops out as soon as the cutter touches the casting it is to face. It is quite impossible to get it to work. I have seen many ingenious devices brought into play for keeping the cutter up to its work, to say nothing of the time spent in fixing them. Taking the drill spindle out and boring a taper hole through it and reaming it when the cutter bar is inserted, as shown, is very



A SUGGESTION FOR THE DRILL-PRESS SPINDLE

simple. The cutter is securely held by the taper pin *A*, and the hole is always there when wanted; of course dismantling a drill to take the spindle out and put it back is half a day's work, whereas if makers would do it before assembling, it would be done in an hour.

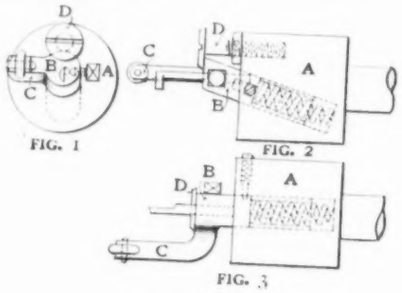
We recently installed two splendid radial drills, by a leading American maker. They were fitted with practically every up-to-date improvement, such as automatic trips, speed boxes, reversing levers, graduated feeds, etc., yet both lacked the above-mentioned necessity. Consequently the first time we used them for facing under bolt holes, we had to take out the spindles and drill and reamer a taper hole as shown.

W. D. PERSHORE.

Birmingham, England.

A Recessing Tool

This tool was made for use on an automatic machine, using three-quarter inch ebonite, making small pieces that had a



A RECESSING TOOL

blind hole in them and a recess at the bottom. It worked well and gave no trouble. Fig. 2 is a plan of the tool. Fig. 1 is a front view of the end and Fig. 3 is a side elevation.

A is the body of the tool, which has a hole bored into it at an angle to take the tool holder *B*. This is a good working fit in the body *A*, and is counterbored to take a spring that is strong enough to overcome the resistance offered by the ebonite to the tool when boring. *C* is a projecting stop that is part of *B*. The small wheel runs on front of the chuck, in the process of working. *D* is an adjustable stop to control the size of the bore, the spring forcing *B* against the head of the screw.

In working, the tool advances and bores the hole to the required depth. The tool was made so that at that depth the stop *C* was hard against the face of the chuck. The body of the tool continues to advance; as the tool holder is unable to advance, it is forced out of position and the tool cuts the recess. As the turret recedes, the spring keeps the tool holder *B* against the bottom of the bore until it is hard against the stop *D*. It then withdraws with the body.

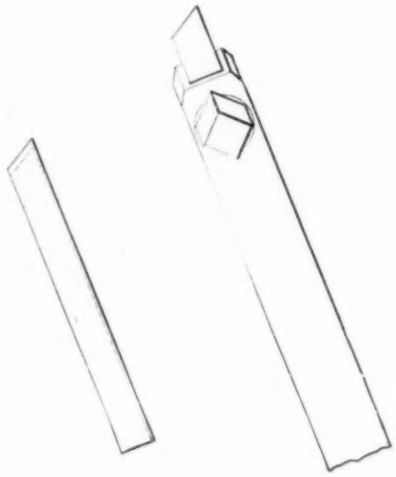
England. J. HERBERT.

Cutting Threads on One Side Only

I have cut many threads by the old way, feeding the tool into the cut at 90 degrees with the center line of the screw, but always found it unsatisfactory, as the tool point would be dull when the finishing cuts were reached.

In order to avoid this an extra tool was used in the Pratt & Whitney tool holder, to replace the dull tool, for finishing cuts. This brought up the idea of grinding the roughing tool with good rake for a "hogging" cut and taking the cut on the side of the V, as suggested by C. A. Marston on page 491, Vol. 30.

In another shop, where no thread tool holder was at hand, good results were obtained by using an ordinary Armstrong tool holder, taking off all or part of the top rake from the cutter, grinding the right-hand side of the cutter straight with the slight clearance on the side, and the clearance on the end for the cutting edge. This makes the top view of the cutter, when at the angle provided by the holder, look like Fig. 1. When placed in the tool post, the holder will take about the same



TOOL FOR CUTTING ONE SIDE OF V THREAD

angle as the compound rest. I use 29 or 29½ degrees for the compound rest; this causes the tool to scrape slightly on the right-hand side of the V, as it is fed into the cut on the left side, the right-hand thread being cut.

Using the Armstrong holder, a dull or broken tool can be easily replaced. It is easier to grind the cutting part when one

side of the tool or cutter is used as a side of the V, as the whole length of the piece of tool steel on that side may be made straight with slight clearance, and all regrinding done on the end, which forms the other part of the V, and on the top.

The point mentioned by Mr. Marston, "having the compound rest at an angle" for convenience in changing and resetting tool, is equally applicable to feeding the cut at 90 degrees. For internal threads also this idea proves a very useful one; and where it can be used, the single chip cut, on one side of the V, will be found much ahead of the old way.

Philadelphia, Penn. E. J. BOWERS.

Repairing Micrometers

Frank E. Shailor speaks rather harshly, at page 632, about the method of truing the micrometer contact faces which my toolmaker friend devised; while I do not wish to champion the repairing of micrometers as a general thing, I would like to point out that they can be faced to a greater degree of accuracy on a good grinder than Mr. Shailor imagines.

In the first place, Mr. Shailor made the mistake of assuming that if the contact faces are worn the threads must necessarily be worn also. This may be true in most cases; but it is not always so, for a careless man can spoil the contact faces much faster than the threads. I have never seen a micrometer in which the spindle would "cock up" when locked with the clamping device, and one of that make would be useless anyhow.

Mr. Shailor's advice about lining up with the table reminds me of the apprentice who was given a very particular job on a planer; this he lined up with great care, using a Brown & Sharpe test indicator and lining from the bed. After getting it true to 0.001 inch, he went ahead and planed it nearly 1/16 inch out of parallel because the cross rail was not parallel to the bed. Of course he should have set his cross rail first; but even as it was, if he had set the work to the tool he would have produced accurate work. The same in resetting work in a grinder, the final and most accurate test is to set to the wheel until it will just draw a few sparks from end to end. The reason that speeding up an emery wheel causes it to show more sparks without feeding any closer to the work is because the diameter of the wheel is actually greater at increased speed; therefore the wheel is cutting more. By feeding away from the work until the sparks only just show again, then the cut is once more around the 0.0001 limit.

Buffalo, N. Y. GEO. P. PEARCE.

A Fine Stamping Job

The quaint old island of Nantucket, off the Massachusetts coast, harbors many curious and unusual objects, brought home in the old days from foreign lands by her adventurous marines.

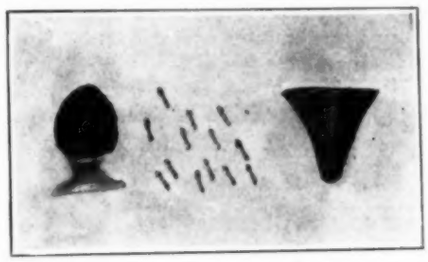


FIG. 1. THE ORIGINAL CHERRY STONE, SPOONS AND FUNNEL

Nearly a century ago Captain West brought from London a cherry stone, the heart of which had been hollowed out and the tiny space filled with the handiwork of a painstaking and skilful silversmith—a gross of silver teaspoons. The first illustration shows the original cherry stone, with an ivory screw plug that closed the opening in the base of the stone, and a little metal funnel to facilitate the replacing of the spoons in the stone.

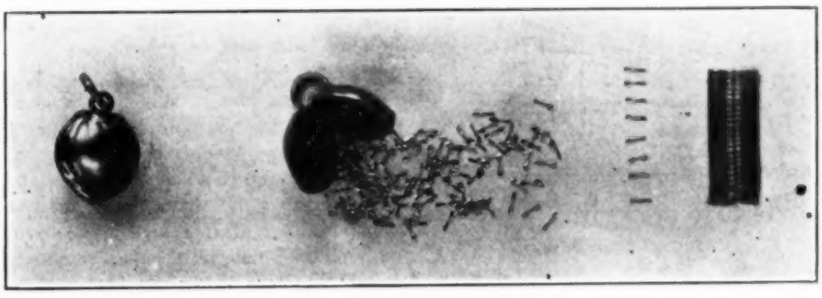


FIG. 2. A COPY, CLOSED AND OPEN, A GROSS OF SPOONS AND THE STRIP FROM WHICH THEY WERE PUNCHED

An enterprising modern Nantucketer, not to be outdone by any British craftsman, has made a die which stamps out and strikes up duplicates of the tiny spoons (except that the new spoons are even smaller and more perfect than the old) with perfectly formed bowls and handles. To contain them he also made a metal locket, the replica of a cherry stone. The second illustration shows the handiwork of the Nantucketer, in actual size. Each spoon weighs one hundredth of a grain, and a light breath scatters them. The strip of silver from which the spoons were stamped is also shown, and it may be noted that they are struck out as economically as is usual in normal-sized spoons.

While the spoons are too small for either ice cream or even after-dinner coffee, and the whole operation might be called useless work by some, it is certainly a good example of fine diemaking and of stamping, and shows what can be done when one sets out in earnest.

Orange, N. J. GEORGE P. SWAIN.

Checking Drawings

I was very much interested in the article on checking drawings, by Mr. Haines, on page 774. I was also much surprised, for while I entirely agree with him on the importance of a thorough checking, I cannot understand why he leaves all his checking to be done after the drawings are traced, thereby making it necessary to work the tracings all over, which is a very unsatisfactory process and gives inferior results. At least, I have always found it so.

Now that I have said what I don't like about Mr. Haines' methods, I will try to give a brief outline of what, according to my experience, gives the best results at the least cost. The drawings should go from the detailer directly to the designer, to be checked by him, to be sure that the details have been carried out according to the design and that all the principal dimensions are correct and properly placed. When this checking is completed, the drawings are ready to go before a committee. This committee should consist of all the persons who are in any way directly interested in the tools that are to be made from the drawings. Let them be criticized from all points of view possible. Any changes that can to advantage be made should be made. If the design is changed, then make new drawings if necessary; repeat this process until the committee is satisfied. When it has approved the drawings, turn them over to the checker. His business should be checking only, not criticizing the design; that part is settled, and he will have plenty to do even if he is a very good man indeed, for he should go over every dimension and rework all important calculations. He should also see to it that all the dimensions necessary are given and no more. Too many figures are nearly as bad as not enough. He should see that all the rules of that particular drawing room regarding the minor details are complied with. When this last checking is finished and the drawings corrected, they are ready to trace; the tracer can go ahead and do a good job, if he is a good tracer, in a short time. The tracings, of course, must be checked, to see that they are like

the drawings, but this is a very simple process.

Hartford, Conn. K. S. ALLEN.

Turret Attachment for a Sensitive Drill

The sketches herewith are intended to show a device which was made to convert a single-spindle sensitive drill into a substitute for a multiple one when occasion required. It is readily attached and is as readily detached when not required.

Fig. 1 is a plan. Fig. 2 is a side elevation partly in section on line *A B*, Fig. 1. Fig. 3 is a front elevation. Fig. 4 is an inverted plan of the contrivance, and Fig. 5 is a side elevation of a Dwight Slate drill press with the contrivance in position.

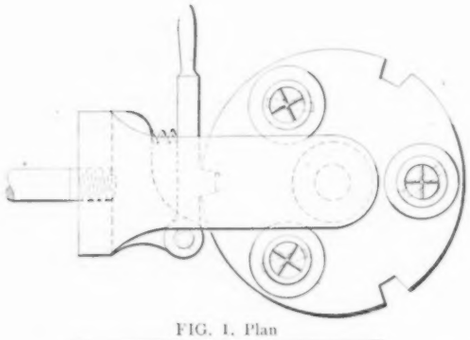


FIG. 1. Plan

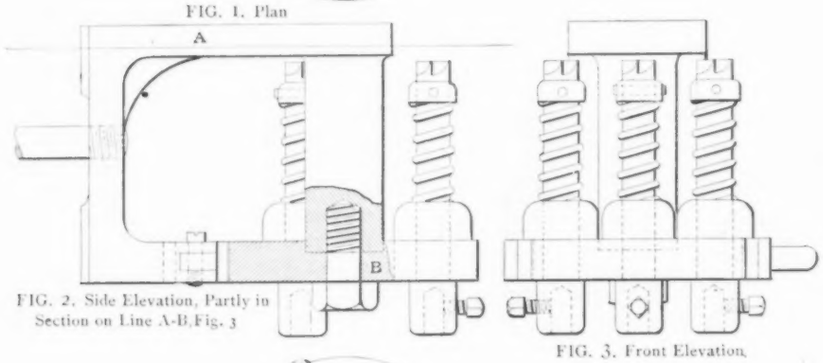


FIG. 2. Side Elevation, Partly in Section on Line A-B, Fig. 3

FIG. 3. Front Elevation

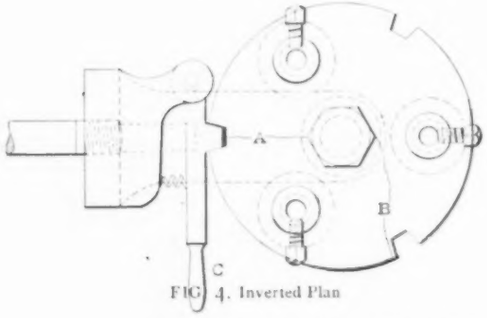


FIG. 4. Inverted Plan

DEVICE FOR CONVERTING SINGLE-SPINDLE SENSITIVE DRILL

It consists of two principal parts *A* and *B*, Fig. 2, both of which are of gray iron. As will be seen, the part *A* is furnished with a tongue, top and bottom, to correspond with the slot in the drill column. It also has a round stem to carry the part *B*. At its lower end is a lug to carry the index lever *C*.

The round disk *B* is fitted carefully to the stem of the main bracket *A* and is held by a hexagon head pin as shown. The disk is furnished with, in this instance, three bosses to give extra length to the three drill-spindle bearings, and also three slots in its periphery by which to index the spindles. The slots were milled in, and then the parts *A* and *B*, with the index lever fitted, were placed in the drill press and the centers for the drill spindles were then marked off in position to insure correct alinement. The holes being bored, they were then fitted with spindles of tool steel having a central hole and set-screw at their lower ends and fitted with collars and clutches at their upper ends. A spring was also fitted to each spindle.

It will be obvious that any other number of spindles could be fitted by having a suitable disk, and also that the spindles could be furnished with chucks at their lower ends, which in this case were fitted with collars to take various sized drills, etc. ROBERT BROWN.

Bournbrook, England.

Apprenticeship

Your report, at page 603, of the recommendations of the committee on apprentices of the machine-tool builders has at

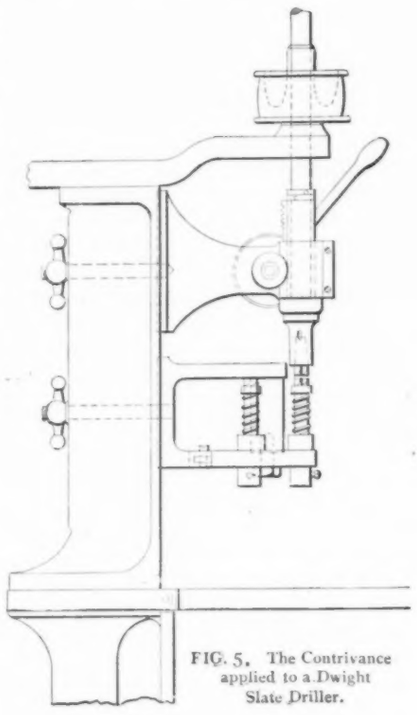


FIG. 5. The Contrivance applied to a Dwight Slate Driller.

tracted my attention, as does everything that concerns the boys in the shops.

I have looked up many apprenticeship arrangements; nearly all seem to forget, as does this committee, that "what is sauce for the goose is sauce for the gander." In other words they suggest holding back part of a boy's pay till his term of apprenticeship is over, as an inducement for him to stay till the end of his course. In this State (Massachusetts) there is a law, which I believe to be just, that any employer who does this shall be liable for an equal amount if he discharge a man. That is, if I hire an apprentice and tell him that if he stays three years I will give him $100 extra bonus, then if he leaves of his own volition before that time I am not liable, but if I discharge him for any reason or without reason at the end of a year and a half, I must pay him the $50, or the proportionate part of his bonus.

My ideas about contracts, written or oral, are a little different from those of most men, and I presume that I may be criticized for what follows. My belief is that it is wise to reduce the most trivial agreement to writing; but I do not believe in making contracts under a bond where there is no escape from their terms, except where there is a possibility that the contract may change hands on one side or the other and that people other than those making the contracts may have to execute them. Men live up to their

word except under stress of circumstance that seems to compel them to break it.

Every few days we hear of a bank president or cashier who has gotten away with a fortune and disappeared. In a few weeks or months we find that he has telegraphed the police to come and bring him back to jail. Back he comes, preferring the freedom of a six-foot cell for a time to the lifelong confinement of a broad world with one country left out. Why does he come back? Just because no man is happy under any restraint except self restraint. Every man, if he is normal, is willing to live under the restraint of laws which he, or his representatives, have helped to make.

Suppose that we have here a boy. His father long ago decided to make a machinist out of him. He himself was probably a blacksmith, a carpenter, but he does not want his boy to have to work so hard as he did, so he takes the young man to Mr. B's shop and they sign a long agreement very much as if it were a prize fight. The boy does not know the first thing about the machine business, does not know whether he will like it or not; he only knows that he has to do what his father says. For a time it is new and the boy does pretty well, but in a year Mr. B finds he has bought a pig in a bag. The boy finds out the same thing; he would rather have been a lawyer or a burglar or something interesting, but he is there nailed down for two years more. He is in just the same state as our embezzler, minus the money. From that time on the condition is simply slavery.

I believe you should take your apprentice as a free man. Do not teach him faster than he can earn. Then if he leaves, you are not out of pocket. The thought that he is free to go if he wishes will take away half the inducement to go. Treat him like a man and let him make a little money once in a while. The shop where I have found the largest lot of good, satisfactory, contented apprentices is one where they let a boy have a chance at piece work every little while. He finds that by learning one step he can make pretty fair money, by learning another that he can make more, and so on. It is only the principle of the "square deal." It will hold the boys that are mechanically inclined, and nothing ought to hold the rest.

Worcester, Mass. ENTROPY.

The Use of a Monkey Wrench in an Emergency

The writer was once called upon to get an automobile in running order after it had met with a collision.

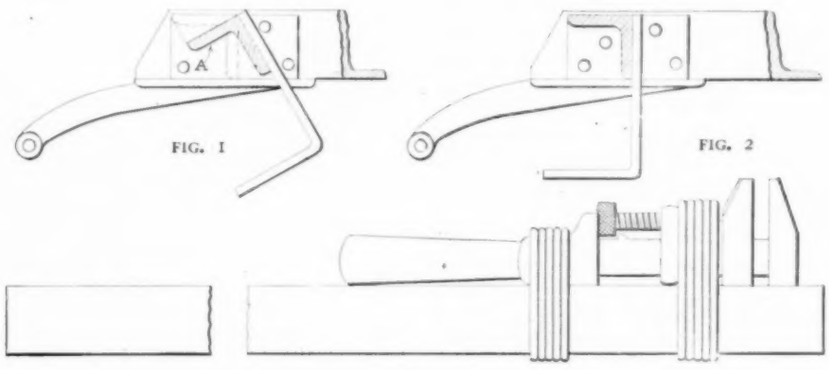


FIG. 1 FIG. 2

FIG. 3

THE WORK AND THE TOOL

The car was standing along the roadside out in the country, with the cooler and its supporting angle all twisted out of shape. This cooler-supporting angle presented an appearance about as shown at *A*, Fig. 1, while it should have been straight, as in Fig. 2. To get the car running it was necessary to get this cross-member straightened. The only available tool was a monkey-wrench.

A wooden bar 6 feet long by 3 inches square was found along the roadside, and the wrench was fastened securely to one end of this by means of a wire, as shown in Fig. 3.

With this long lever arm on the monkey-wrench, the steel angle was straightened very easily, the cooler was placed in position and the car proceeded on its journey.

Hartford, Conn. E. A. CHARLES.

Repairing Drills That Have the Tangs Twisted Off

A splendid way to fix tapered-shanked twist drills that have the tangs twisted off is shown in the accompanying illustrations. We have used this method for some time, and find that it is the best and cheapest way that we have yet seen.

The twisted tang and about ⅛ inch of the shank is ground off so as to leave the drill as shown in Fig. 1. A small V-groove is then cut in the tapered shank about 1/32 inch deep, as shown by the dotted line, Fig. 1. We cut these grooves with the milling machine, but they can be cut quite as well with a shaper.

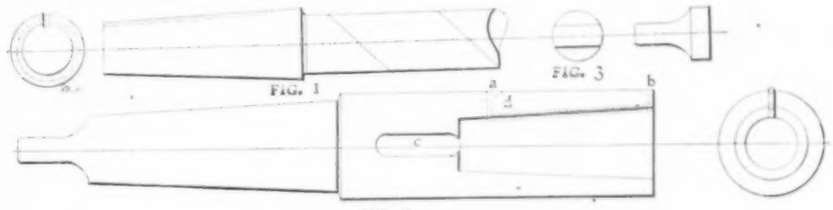


FIG. 2

REPAIRING DRILLS WITH BROKEN SHANKS

Fig. 2 shows the socket for holding the drill when in use. This is made of an ordinary socket with a groove cut in it, similar to those cut in the tapered shanks of the drills. A 1/16-inch hole *a* is drilled to meet the groove. We cut the grooves in the sockets by using an extension tool in a shaper. Another groove 1/16 inch deep is then cut in the end, as is shown at *b*, and still another short one, as shown at *d*. A piece of piano wire 1/16 inch diameter is then inserted in the slot and bent over as shown by the dotted lines, Fig. 2. The bending over of the ends is done simply to hold the wire in place.

When one of the drills fixed as shown in Fig. 1, is inserted in the socket, the taper holds the drill true and central, and the wire, half of which lies in the socket and half in the groove cut in the shank, prevents the drill from turning. Drills fixed in this manner do better service than when new, as far as holding them firmly is concerned. The drill will break before showing even the slightest tendency to turn.

To provide a means for removing the drill, we inserted a piece, Fig. 3, in the socket. The wire prevents this piece from falling out. We sawed the tang and a small portion of the shank from a broken drill for this piece, and it answered the purpose admirably. To remove drills from socket then, the common key is used.

We had a large bunch of drills, the accumulation of several years, out of service on account of the tangs being twisted off, which we put to work again by this method, and they are giving good service. In fact, some of the machinists prefer them to new drills, because all danger of twisting is obviated.

Columbus, Ohio. G. ROY.

A Punching Die

In the AMERICAN MACHINIST, at page 312, there is an article, "A Punching Die," The tools that did do the work are all right in a way, say for light blanking, but for heavy work there is too much chance left to the operator of damaging the tool. No doubt the tools have worked, but at the same time, in my opinion, the design is not up to date. As your paper is intended for our instruction, not only in showing us how a job can be done, but the different ways there are of doing it, with their respective advantages, I submit that in the tools shown in the article referred to there is nothing to prevent the bar of steel being pushed against the stop at an angle, so that the punch would not have an equal amount of metal to cut on both sides; on material ½ inch thick that would be disastrous to the punch if not to the die, as no doubt the punch has been left considerably softer than the die, which would mean shearing the punch. Perhaps, the material being thick, the punch does not enter the die, which means that the tools are not damaged; but the result is a bad blank, and there is the

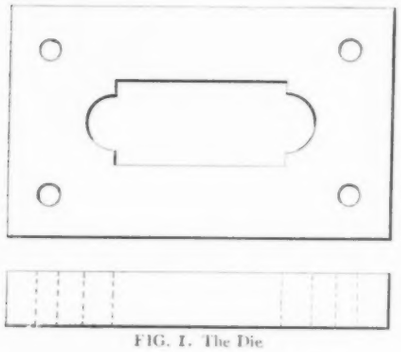


FIG. 1. The Die

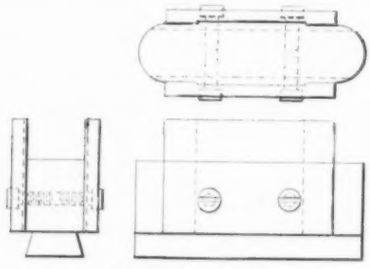


FIG. 2. The Punch

A PUNCHING DIE

chance of having a good many bad ones, as it is sure to spring or force the punch out of line.

A SUGGESTED IMPROVED DESIGN

Now in the sketches I am sending there is no possible chance of the tool getting out of line; the life of the tool is prolonged, as the punch is always in the die and the metal is always in the center and cannot get out of line. Of course it is only since the makers of steel could supply material up to gage that this class of tool could be used to advantage. Years ago, when 1 9/16 inches was considered near enough to 1½ inches, the same trouble with irregular ends would have happened with this tool as with the other.

THE DIE

Fig. 1 is the die made of steel-faced iron. For a 6-inch link I should have a piece cut off 12x8x2 inches, half steel, half iron. On a line through the center leave two holes, 6 inches center, 2 inches diameter; taper them 1/16 inch taper in the 2 inches. Then across the center line machine the gap 3 inches wide, making it ½ inch wider on either side, leaving this part of the die parallel and the edges well rounded, so that as the punch enters it will not scrape the metal, as the only portion of the die that is left with a cutting edge consists of the two ends that form the link. Four holes are put in for fixing to a bolster plate or bed of the press.

THE PUNCH

The punch, shown in Fig. 2, is machined as in the sketch, with projections on both sides, to fit the two plates that are bolted to the side of the punch, acting as guides as the material is being cut. The two plates are left longer than the stroke of the press in proportion to the length of the punch, so that when set they are always in the die. The plates are fitted to the sides of the punch so as to leave a gap for the metal to be pulled through, insuring that the ends shall be sheared true with the sides of the material. The side plates are recessed to fit the punch, so that when the plates are bolted on there will be formed practically a solid punch.

The stop is not shown, as the ordinary stop fixed to the die or an automatic feed can be used, there being nothing fixed on the die, as this method does away with the guide plate.

The two plates on the side of the punch are made in separate parts so that at any time the face of the punch can be ground. The punch is made so that it can be driven in a press shoe or punch holder.

C. PETITJEAN.

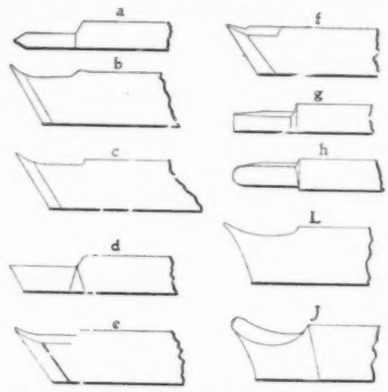
London.

Another Way of Cutting V-Threads

At page 491 Mr. Marston describes a method of cutting threads by setting the compound rest over to 30 degrees. Now I will say that he is on the right road, but has not by any means arrived at the limit of rapid thread cutting.

As Mr. Marston takes soft steel as the basis of his article, I will also, as it is the most difficult material except copper to cut a clean thread on.

I think he will experience some difficulty in cleaning up by going straight in at the bottom, besides losing time. Again, by using the compound screw to operate the tool he is working at a disadvantage, for it is my experience that compound heads are as a rule the most ungainly things imaginable where quick action is necessary. It is a strange thing but nevertheless true that three-fourths of the machinists do not know how to cut a clean thread. How



TOOLS FOR VARIOUS KINDS OF THREADS

many otherwise nice pieces of work do we see disfigured by a ragged thread!

I do a great deal of thread cutting, and the accompanying sketches will show the shape to which I grind the tools. *a* is top view and *b* side view of thread tool for very soft steel, *c* showing the finishing tool. It will be noticed that *b* has lots of clearance and a circular top rake; while *c* is the same in clearance, the rake, which is extreme, is on a straight line. Some will say you can't cut a perfect thread with a tool like that, and I will admit that the operator may have a little difficulty at first; but by experience he will learn how to try the gage on this shape of tool. It is enough to say that a perfect thread can and is being cut with tools of this shape.

To operate, set the compound rest at about 10 degrees; place tool *b* in the post; take at first as deep a cut as you can without tearing the edges of your thread, turn the compound screw enough to make almost a full thread. Next tighten the gib in the cross slide enough to hold the tool to its work; turn the compound screw ahead slightly again; run the tool below the depth, and as it comes up to the work back out enough to maintain a light cut. Then back off the compound screw about twice the amount you forced it ahead the last time, and in the same manner take a cut up the other side; you will have a fairly clean thread. This can be done at a speed of 40 feet per minute.

Now slow down to about 25 feet; wash off the oil with sal soda and water. Set tool *c* and take another light cut up each side, being careful not to quite touch the other side, and you will have a "looking-glass" thread in six cuts. The tool is operated by the cross-slide screw always.

Sketches *d*, *e*, and *f* represent a rougher and finisher for a brace or buttress thread. It will be noticed that the rake and clearance are the same except that the top of

the tool is ground low ahead to throw the chip away from the straight side of the thread.

The operation is the same, except that only a slight movement of the compound head forward is all that is required at each cut, merely to keep the cut from crowding against the straight side. Now set tool *f* and clean up the angle side of the thread; then back up on the compound head enough to clean up the straight side.

Sketches *g, h, i,* and *j* show the shape of rougher and finisher for square thread; they require no explanation, except that the rougher is fed ahead at each cut. In threading harder metals the rake and clearance must be modified until we reach high-carbon steel, when the finishing tool has but little rake.

If D. Clifford will go over this article, I think he will be able to solve his problem.

Erie, Penn. J. WATSON.

Use of Oil in Hardening

Many times in the hardening of pieces of steel, heavy and light sections are so located that the sudden chilling and hardening of the light portions subject them to great strain, while the heavy parts continue to contract and alter in shape and size during the longer time it takes for them to cool, thus producing a source of trouble.

My attention has been called several times of late to articles that gave a great deal of trouble when hardened, and the difficulty arose in every case from an irregularity in size of the various portions of the piece, thus causing unequal contraction in the bath. As the thin portions hardened more quickly than those that were heavier and thus were brittle and unyielding, they were pulled apart by the change in size and shape of heavier portions as they contracted.

After an examination of the articles, a method of hardening was adopted which entirely eliminated the trouble. Thinking that possibly some reader of the AMERICAN MACHINIST might be interested in the method pursued, I submit drawings of some of the pieces, and will tell what was done to get rid of the trouble.

Fig. 1 shows an article made from tool steel of a good grade which showed a tendency to crack when hardened, the cracks running from the bottom of the cuts to the hole passing through the center, as shown at the dotted line *a*.

METHODS TRIED

I found on investigation that various methods of hardening had been employed, all proving alike unsatisfactory. It was necessary to harden the faces of the projections radiating from the center and to have them hard way to the bottoms of the openings, and it was not possible to fill the bottoms of the openings with anything like fire clay, to prevent the surfaces from hardening at these points.

They had tried dipping the pieces first in water, removing them from this liquid when they ceased "singing," then plunging them in oil to cool off slowly. Now this method is many times employed with most excellent results; but in the present case the pieces cracked before the *heavy* part stopped "singing."

The method adopted was to heat the piece carefully to insure *uniform* heats; then with a well oiled cloth we wiped the surfaces of the projections at the lower part of the opening. This was done by drawing the cloth through the openings; it was then drawn through the hole, after which the piece was plunged in a bath of warm water and worked around until it had cooled to the temperature of the water.

At first thought it might seem wise to use a bath of the description shown in Fig. 2, this being a bath of water with a surface of oil, as shown; but this form of bath would deposit oil over the whole surface, and thus retard the cooling of the entire piece, while the application of oil to the light section retarded the cooling at this point and no other, thus insuring its remaining in a pliable condition until the heavier parts had contracted sufficiently to do away with a tendency to crack, as shown in Fig. 1.

PUNCH PRESS DIE

Another job of hardening that came to my attention was a punch-press die of the form shown in Fig. 3. The die was made from a block much larger than would seem advisable to one familiar with the effects of unequal expansion and contraction of steel, having heavy and extremely light portions so arranged that the heavy portions would continue to contract after the light portions had hardened and become rigid and unyielding.

Several of these dies had been made, and all cracked when hardened, the cracks running as shown by the dotted lines *b*. An examination of a small piece of steel cut from the end of the bar from which the die block was made showed, when broken, a fracture with coarse grain, thus proving that the steel had been overheated when annealed. Steel in this condition should be annealed again, to restore the grain and strength before the steel is hardened; so we heated it to a good low red heat and allowed it to cool in the air, after which it was heated to the proper hardening heat, extreme care being exercised to get a uniform heat in order to insure as nearly as possible a uniform contraction when the steel was cooled. The surface of the walls of the opening where the adjoining openings came nearest together were oiled by means of an oiler; the edges *c* and *d* and the corners were well oiled. The die was then dipped in a bath of *warm* water and worked back and forth in the water, to force the liquid through the openings and insure the hardening of the walls of the opening. The die came out all right and worked nicely when used. I am informed that several dies similar in shape to the one described have since been treated in the same manner with excellent results.

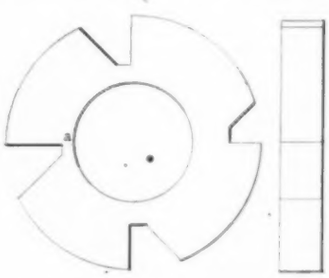


FIG. 1. MILLING CUTTER

FIG. 2. QUENCHING TANK

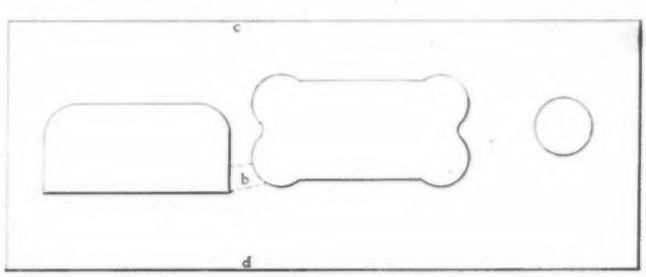


FIG. 3. PUNCH DIE

RETARDING RADIATION

The light sections of steel give off their heat so much more rapidly than the heavier portions that it seemed wise to apply the oil to their surfaces in order to retard the radiation of heat and thus keep the pieces from too rapid chilling, thus giving them a chance to yield as the heavier parts contracted and strained them.

Many times it is wise to place oil on the corners and edges of dies, especially those made from *large* pieces of steel. In this way we prevent rapid cooling of these parts, which need not be hard, and so do away with a tendency of the corners to crack when cooling.

When heating pieces of steel of the description just considered, extreme care should be exercised that corners and light sections do not become overheated. These portions, even though they cool down

while the heat is equalizing, are weak and are liable to break away, or at least to crack, when quenched.

After all, the secret of success in hardening steel consists in proper heats, uniformly applied, and uniform contraction when cooling. The hardener must use his judgment as to the best way to attain these results.

Cambridge, Mass. E. R. MARKHAM.

Limit of Accuracy in Calculations

Mr. Senyours' article on the slide rule, printed on page 595, seems to call for some defense of the paper and pencil method of making calculations. A large number of men who do not use the slide rule have good and sufficient reasons for their attitude in the matter. The results of the calculations on the slide rule lack the accuracy necessary for many machine-shop uses.

In general, the techincal schools teach the use of the slide rule quite thoroughly; as a large number of men start their practical engineering experience in the drawing room, they attempt to determine the dimensions of the parts of machines by the aid of the rule, only to find out that in nine cases out of ten the results are not accurate enough. Most work done in the machine shops of this country calls for a greater degree of accuracy than that shown by the example cited by Mr. Senyour. Modern manufacturing requires work to be done on the interchangeable system, which calls for exact dimensions and for special tools, such as jigs and fixtures which are accurate to a fraction of a thousandth of an inch. This accuracy the slide rules will not give, and in course of time they are stowed away in the back of the tool drawer and seldom used except as a rough check. If the operation of the slide rule gives a correct reading to the thousandths place in a decimal fraction without any guessing as to the last figure, it is of course all right; but there are few occasions where such a combination of figures occurs. It far more often happens that the last two figures will be at variance with the more exact calculations made with the paper and pencil.

Many times one side of a triangle has to be determined from the other side or from the angle, requiring a result accurate to the thousandth place. Such a solution is clearly impractical with the ordinary slide rule. Let us suppose a case, using the same figures which occur in Mr. Senyour's article, only introducing a decimal point after the first two at the left hand, making the multiplication read 6.86×2.57. From the slide rule the result would be 17.6200. By the paper and pencil method the result is 17.6302. This shows a difference of a hundredth of an inch should the figures represent inches, which is an error ten times greater than most detail work would permit. Should the decimal point be shifted another place to the left, we would have the multiplication 0.686×2.57. The result by the slide rule would be 1.762 and by the paper and pencil method 1.763. This gives a difference of a thousandth of an inch, which again is clearly not accurate enough for much machine work.

Another feature in favor of the pencil and paper method is the fact that the man with the slide rule has no record of the various stages of his calculation and cannot verify the correctness of his work at any future time except by completing the entire series of calculations. To be sure there are slide rules made which will read accurately to a much finer degree than those ordinarily in use; but the cost of these is prohibitive for the average draftsman and designer.

Salem, Mass. N. P. LOGUE.

Brazing Cast Iron in Auto Repairs

I have found Ethan Viall's receipt for a flux for brazing cast iron to work very well; but since making it up I have tried mixing up borax and spelter with half and half muriatic acid and water, and it gives good satisfaction. I have brazed the end plates of mufflers that were broken into several pieces. These plates are rarely over ⅛ inch in thickness and from 4 to 8 inches in diameter. After being brazed, they will break much easier in a new place than where they are brazed together.

I find his method, in brazing cast iron, of not using the flux until he has a good red heat a good one, also that heating it at a brazing heat for about twice as long as for wrought iron helps a lot. I take a file and checker the edges where they come together and then bind as tight as possible; I have no trouble about the spelter flowing in the joint.

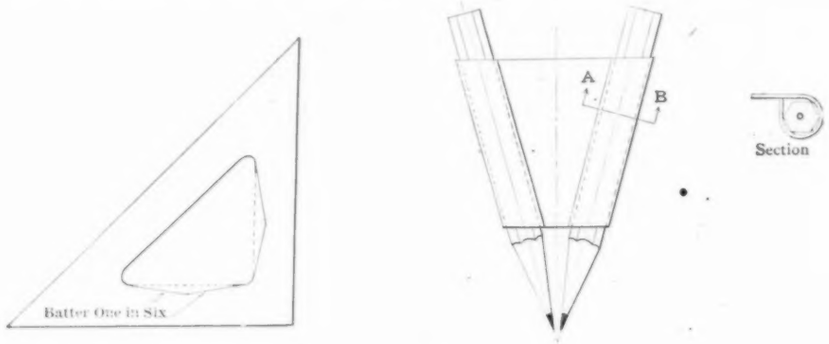
We repair men in the auto business are often looked upon by a good many people as benighted heathen, particularly by some but not all of the factory experts who visit us, also by all the chauffeurs who have had a course of instruction at the works for a few weeks to get acquainted with the new cars. I have had a number of the latter insist upon having the parts I was working on for them made from tool steel and case-hardened; also one, a few days back, wanted some 6x⅜-inch hex head bolts for the differential of a big car turned from stubs-steel drill rod.

Washington, D. C. F. L. NICHOLS.

Handy Kinks for Draftsmen

In one of the recent issues of the AMERICAN MACHINIST a homemade device was shown for drawing in the sloping sides of the flanges on I-beams and channels. It consisted of a piece of transparent celluloid with one side battered one to six.

A somewhat handier arrangement is illustrated by Fig. 1. It consists of an ordinary triangle with the horizontal and vertical inner edges battered one to six. This avoids the use of the extra piece referred to above, and therefore is quicker and less awkward. As shown, the flanges of I-beams standing horizontally or vertically may all be drawn in without turning the triangle over or reversing it.



TWO KINKS FOR DRAFTSMEN

Another excellent scheme is to have the three inner edges of the triangle battered to make angles of five, ten and fifteen degrees, respectively, with the three adjacent outer edges. Then combinations of these six sides may be so chosen as to give an almost complete series of angles advancing by increments of five degrees. By substituting other angles for these, different series may be obtained.

Fig. 2 shows another excellent device for use in the drafting room. It finds its use in the drawing, with one stroke, of two parallel lines to be used as guide lines for lettering on a drawing. It consists of a thin sheet of tin or aluminum, bent as shown, with two common lead pencils held in the pockets at each edge of the sheet. These pencils may be readily moved up or down to vary the spacing of the lines, and can easily be removed for sharpening. This instrument is a time saver, but its chief merit lies in the fact that by its use the lettering on a drawing

is much more uniform in hight than when the guide lines are spaced by guess, and the work presents a neater appearance.

Detroit, Mich. A. L. CAMPBELL.

Why Do V-Blocks of Machine Steel Flake Off?

There are a number of instances in the manufacture or design of tools and fixtures where either soft machinery steel case-hardened or tool steel hardened may be used with nearly equal success, as for instance in bushings; but we have found that for V-blocks and pieces on which heavy pressure is brought to bear by the work being machined, the use of machine steel is not feasible. The reason for this is that under constant pressure the structure of this steel is such that it flakes off along the line of contact of the work (especially where the work is cylindrical in shape), rendering the locative or holding qualities of the tool poor.

I am not a good enough metallurgist to explain the reason for this action of the lower carbon steels, but know from experience that this is the case. Perhaps some of your readers can explain it.

Detroit, Mich. M. R. KAVANAGH.

Cylinder Boring Cutter

The following is a description of a cutter head I recently made for rough boring gas-engine cylinders. The tool consists of a body *A*, Fig. 2, tapered for a No. 5 Morse and beveled off as at *N* for the four tools 1, 2, 3, 4, Fig. 3, to rest against. Four slots are milled as at *a*, Fig. 2, for the adjusting blocks to slide in; these blocks are adjusted by the four adjusting screws *b*. The collar *B* is slotted and milled, as shown in Fig. 1. *B* is slipped over *A* and firmly held in place by the taper pin *C*. The tools are held in place by the four set-screws *g*, Fig. 1. The tools were stepped off as shown in Figs. 1 and 3. No. 1 cutter is ground to size; No. 2, 1/32 lower; No. 3, 1/16 lower; and No. 4, 3/32 lower. Fig. 3 shows the method of stepping them off endwise. With a 3/16-inch feed this tool roughed off ¼ inch of stock with ease.

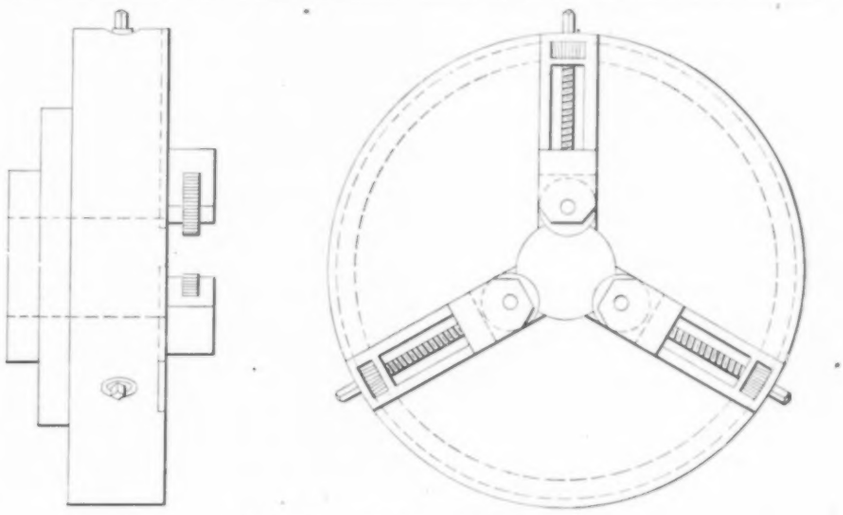
Port Huron, Mich. L. A. P.

Nurling Work in Long Lengths

Some time ago we had a lot of wire of various sizes to nurl. An old three-jaw self-centering chuck was taken apart and the jaws annealed, after which they were slotted as shown, to receive the nurls. The wire was in coils and was mounted on a turntable at the rear end of the spindle. After passing between straightening rolls it was led through the spindle between the nurls and grasped by a clamp held in the tool holder. The jaws of the clamp were shod with copper so as not to mar the work. A set-screw held the circular rack after the nurls were adjusted to depth. The carriage as it receded from the chuck drew the wire through the straightening rolls and the nurls.

The only scrap was about 2 inches on the beginning of each coil. The nurls were about 1 inch diameter. They would nurl any size from about 5/32 inch up to any size that would pass through the chuck, which was about 1¼ inches in this case. The nurling was done with a liberal supply of oil flowing on the nurls. After nurling, the wire was cut in 6-foot lengths.

E. A. DIXIE.



THE CHUCK ARRANGED FOR NURLING

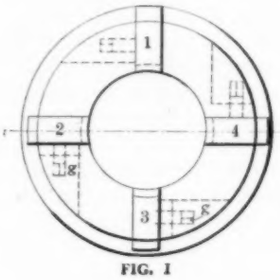


FIG. 1

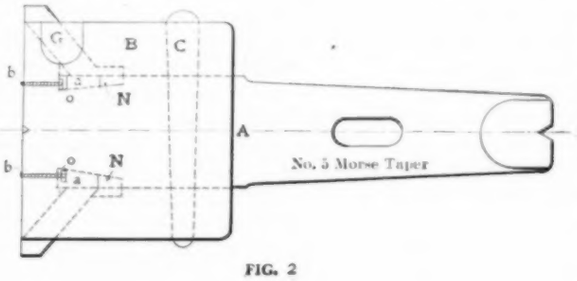


FIG. 2

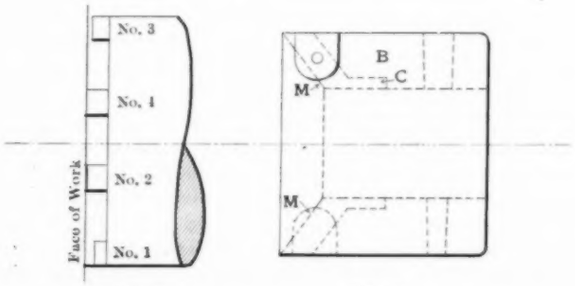


FIG. 3

FIG. 4

CUTTER HEAD FOR BORING GAS-ENGINE CYLINDERS

Shrink-rule Device

The shrink-rule substitute shown by H. B. Foster, at page 808, seems to be a rather ingenious application of the diagonal scale, but I must confess my inability to see how it works, as Mr. Foster's description of its use is to me a trifle hazy. If his scale S is a standard scale, it looks to me as though the hights taken from it in its inclined position by the surface gage would be *less* than standard instead of greater, as a shrink-rule measurement ought to be. His inclined scale, as he shows it, would be all right for getting standard hights from a shrink rule, but I would like him to tell us how he works it the other way and gets shrink-rule sizes from a standard scale.

Brooklyn, N. Y. WALTER GRIBBEN.

According to *L'Electricien*, a Vienna firm has recently placed on the market brushes made of glass, which are to replace emery cloth for cleaning and polishing the commutators of dynamos and motors. These brushes are said to clean the commutators without scoring the metal, and their use avoids the inconveniences and dangers of emery cloth.

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Use the Standard Machine Screws

The standardizing of any article which enters into machine construction is of equal importance to both maker and user; even if the sizes adopted do not agree with the individual idea as to proper proportion, it is better to adopt the standard so as to be able to duplicate parts at any time. While the old half-inch bolt with its twelve thread may have seemed better to some, the advantage of always having bolts alike more than compensates for the nervous shock of having to use a thirteen thread.

The new A. S. M. E. standard of machine-screw sizes has been criticized to some extent, partly from a misunderstanding of its aim and the way in which it is accomplished. No one would think of starting fresh with any such list of sizes as those given, but it must be remembered that the machine-screw business has been a growth, beginning with the American Screw Company, and that all the rest have either followed their sizes as nearly as could be measured from screws purchased in the open market or else started on new lines with the idea of being different.

As a result there have been untold millions of screws made and used of different standards; in order to get any kind of a standard which could hope to become commercial, it was necessary to keep as near as possible to the existing sizes of the largest makers and yet maintain some sort of a ratio so that new gages could be originated if all the old ones were destroyed.

To this end the veteran tapmaker, J. M. Carpenter, was one of the leading spirits in the last revision of the proposed standard; as adopted, the tables come as near to satisfying all the conflicting interests as seems possible in a compromise of this kind, and it seems the part of wisdom to adopt these at once and to mark all orders for machine screws, "A. S. M. E. Standard."

There is little doubt that Mr. Carpenter has been the largest maker of machine-screw taps in the United States and that the change meant more to him than to anyone else, yet he has not made a tap by his old standard, for stock, since the first of July of this year and is making the new sizes in all cases unless otherwise ordered. This is the best evidence we know of regarding the new standard being practical and that it is coming into use whether we exactly fancy it or not.

The flat top and bottom is easier for the screwmakers; and by using the right drill in the hole, which is given in the table of standard taps, the tap can have a sharp V at the bottom and still leave the thread right for the screw, so that the apparent difficulty of making taps with just the right flat at the bottom of the thread is overcome in a very practical way.

The new threads follow the United States Standard thread in both the amount of flat and the depth for any given pitch, while the allowances for variation between maximum and minimum have been carefully considered so as to allow as many of the screws now in stock to be used as possible.

It is not expected that the screws now made shall be scrapped, although in some shops it will probably pay to do so; but it is earnestly urged by screwmakers and tapmakers that the present confusion be done away with as soon as possible. In this each user can help by insisting on all new screws being the A. S. M. E. Standard, even if it does mean throwing away a few small taps.

Efficient Foremanship

A short time ago, while walking through a machine shop of a large machine-tool building firm, the superintendent called our attention to a middle-aged man standing in front of a bench near a group of automatic gear cutters and engaged in testing a gear which had apparently just been cut. Six years ago that man was a common laborer and was at work cleaning old bricks just before entering his present employer's service. The superintendent with whom we were talking needed help, noticed this man at his laboring work, hired him, found him capable, took an interest in showing and teaching him, and today he has charge of all of the automatic gear cutters, cutting thousands of gears each year, in the shop which he entered as a common laborer.

On the following day we visited another machine shop and the owner pointed out an active man at work on a group of milling machines. Four years ago that man was carrying castings around the shop, snagging, sweeping the floor, and doing all kinds of laboring work. A milling-machine hand was needed and the foreman decided to give him a trial, at the same time interesting himself in the man's progress and instructing him thoroughly in the details of the use of the machines. Today that man is a working second hand on a milling-machine job having a large variety of machines.

The advancement of these two men from the rank of a common laborer to that of a skilled mechanic doing executive work shows plainly the efficient foremanship under which they have worked. Such foremanship is to be commended, and presents a striking comparison with the attitude of the foreman who requires the most skilful workmen throughout his department in order, if possible, to cover up his own deficiencies. A manufacturing machine-shop department filled with high-priced help is apt to run itself, rather than to be run by the foreman in charge; but the man who can produce the quantity of work required, at a reasonable cost and with efficient labor, though not neces-

sarily highly paid, is the one who is getting real results. The unskilled man works for low wages for two reasons: one because of his inability to produce through lack of knowledge and training; the other because he must pay, indirectly of course, for the necessary expert supervision in order that he may produce to the advantage of his employer. This expert supervision comes through the medium of his foreman, and it is his right that he should be properly instructed in order that he may gain in efficiency.

Men who are lifted from the position of the common laborer to that of the skilled operator often become the best men in manufacturing departments and add an element of strength to the factory's organization because of the relationship which exists between them, as efficient workmen, and the foreman who has been instrumental in increasing their efficiency. A successful foreman should produce the work from his department in a large quantity, for a low price, with all of the necessary elements of accuracy and with efficient labor. Successful foremanship, in the future still more than in the past, will train and develop unskilled laborers into efficient producers. However, such development is of necessity special and cannot take the place of a broad training in general machine-shop lines.

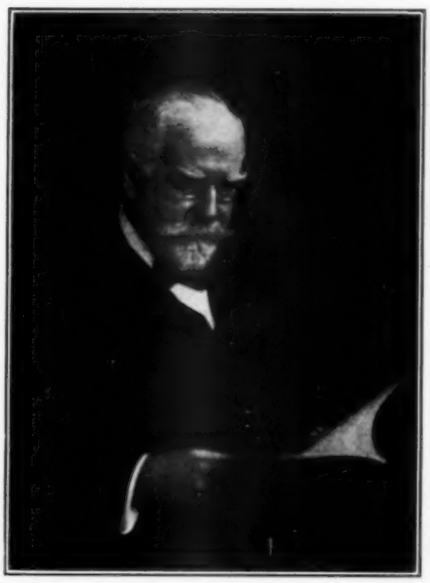
Dr. Coleman Sellers

Dr. Sellers, who died at his home in Philadelphia, December 28, was born in Philadelphia, January 28, 1827. At the age of 11 he entered the academy of Anthony Bolmar, at West Chester, Penn. While there his interest in natural philosophy was first stimulated by the simple experiments used as illustrations by the instructors. Even as a boy he was studious and methodical, for while at school he kept a diary in which he noted from day to day those things which interested him.

Under the date of November 3, 1842, he states that he began to make a hygrometer. This was made of a piece of catgut running over several pulleys, one end being fastened to the board upon which the pulleys were pivoted and the other end connected to the indicating needle. A crude sketch of the device accompanies the description. He later mentions a proposed improvement of his own in which he substituted a spring for the weight on the indicating point so that the hygrometer would work in any position. As a further improvement still later he suggests using a piece of ash instead of the catgut and compound levers to obtain magnification at the indicating needle. "It is to be made pretty much on the same principle as those instruments which show the expansive power of metals, only instead of metal, a piece of ash is used as the body to be expanded, and instead of being acted on by heat, it is acted upon by the atmosphere."

His thirst for knowledge compelled young Sellers to study by himself such subjects as botany and mineralogy, which were not included in the curriculum of the school.

Much of his spare time was devoted to making apparatus to illustrate the facts and theories imperfectly taught in the lecture room. He completed his course at Bolmar's Academy in his seventeenth year. It was his mother's desire that he should be a farmer and in submission to his mother's wish he spent the next two years on the subject of agriculture. During this time he invented several farming implements, notable among which was a metal-toothed hay rake mounted on



DR. COLEMAN SELLERS

wheels. In 1846, at the age of 19 years, he was offered a position in the Globe Rolling Mills, Cincinnati, O., run by his brothers, Charles and George Escol Sellers. While there he designed improved machinery for rolling iron for Horatio Allen, proprietor of the Novelty Iron Works, New York. This work interested him in acquiring knowledge of the rolling of merchant iron, wire rods and flat rails, used at that time in the West. Before he was 21 he was superintendent of the Globe Rolling Mills. During 1850 and '51 he was occupied building locomotives, invented by his brother. In 1851 he accepted the position of foreman in the locomotive works of James and Jonathan Niles, Cincinnati, O., where he stayed till 1856. In 1856 he took charge of the drafting room of his relatives, Wm. Sellers & Co., Philadelphia. His experience in locomotive building had convinced him that better tools were required to reduce cost and improve the quality of work. During the next 30 years much of his time was devoted to the improving of the general run of machine tools and special tools. He also designed many machines, not strictly classable as machine tools, such as hydraulic cranes, hoists, elevators, presses, forging machines, engines, pumps, injectors, turntables, pivot bridges, etc. Among the best known of his inventions is the Sellers double-cone coupling.

He took up photography, a new art, in 1858, and made many notable improvements and discoveries in the art. The kinematoscope, the first moving-picture machine, was patented by him in 1861. When in Philadelphia he took up the work of the Franklin Institute with earnest zeal and was vice-president of the institute for several years.

He was a charter member of the American Society of Mechanical Engineers, and for their meeting of 1880 wrote his much quoted paper entitled, "The Metric System, Is it Wise to Introduce it into our Machine Shops?" He was well known for his antagonism to the enforcement of the use of the metric system.

Besides being a member of the leading engineering societies of this country, he was a member of the Institution of Civil Engineers, the Institution of Mechanical Engineers of Great Britain, and the Geneva Society of Arts. In 1877 the Royal Norwegian Order of St. Olaf was conferred upon him by the king of Sweden in recognition of his valued services in his profession. He was a member of the American Philosophical Society, and was one of the founders and for a time president both of the Photographic Society and the Pennsylvania Museum and School of Industrial Art of Philadelphia. After he had shown up the frauds of Katie King and the Davenport Brothers he was made a member of the Seybert Commission of the University of Pennsylvania for the investigation of the claims of spiritualism, being chosen in consequence of his active and clear perception of the laws governing cause and effect and his knowledge of sleight of hand, in which he had been an expert since boyhood. The honorary degree of Doctor of Engineering was conferred upon him by Stevens Institute, Hoboken, in 1887, and that of Doctor of Science by the University of Pennsylvania in 1899.

In 1889 he was requested by Edward D. Adams to report on the practicability of generating electric power at Niagara Falls and transmitting it to Buffalo. His report so strongly indorsed the scheme that a company, the Cataract Construction Company, was formed and he was appointed consulting engineer for it.

In June, 1890, he assisted in establishing the International Niagara Commission in London, England. This commission consisted of the late Lord Kelvin, chairman; Dr. Coleman Sellers; Lieut. Col. Theodore Turrettini, of Geneva, Switzerland, engineer of the water-power plant on

the Rhone, and Prof. William Cawthorne Unwin, dean of the central institute of the guilds of the city of London, as secretary.

The commission awarded $22,000 in prizes for plans for generating power by water and transmitting it to a distance by the most economic method regardless of the medium of transmission.

Dr. Sellers was more than able to hold his own with these men and on several vital points, which meant everything to the future of the generation of power at Niagara, he differed from his associates, and it was his ideas that were put into effect. Lord Kelvin, for instance, was in favor of the use of a direct current, while Dr. Sellers favored the alternating current, and it was the alternating current that was utilized, Lord Kelvin several years afterward admitting his error in the matter.

The mechanical problems of the dynamos, whose wonderful adjustment has been a subject of admiring comment ever since, were as devised by Dr. Sellers and not by Professor Forbes, one of the foreign consultants. Moreover, in finishing up the work at Niagara, the board of consulting engineers was dissolved and the electric hydraulic and mechanical problems were put solely into the hands of Dr. Sellers. Of his work here, Dr. Henry Morton, the late president of Stevens Institute, said that his foresight in judgment in adopting methods which were without precedent made the Niagara Falls project a crowning achievement of a remarkable lifetime.

His active connection with the Niagara Falls plant did not terminate until two years ago, although of course he did not devote his entire time to its requirements. He also conducted a general engineering business and was consulted on a variety of work, especially on water-power electric projects. Perhaps the last important constructive work in which he was personally engaged was the reconstruction of the Rochester light and power plants. He also appeared in a number of important patent cases and examined and reported on many schemes of different sorts. He gathered about him a competent staff of assistants and since the failure of his eyesight had been obliged to delegate all details to others. He retained his mental activity to a marked degree and even in his last sickness constantly astonished his friends by the accuracy of his memory and his clear perception of principles.

The Machinery Club

We are in receipt of some information from the Machinery Club, whose temporary office is at 26 Cortlandt street, New York, indicating that the plans for the club are making excellent progress and that its success is assured. The great Fulton Terminal building, which is to contain the headquarters of the club, is rapidly approaching completion and the club is expected to open for business the first of May. One of its features, which will be unique for a down-town luncheon club, is to be a roof garden, which, overlooking as it will, the North river and the harbor, will offer attractions for a noon-day luncheon in hot weather which are unequaled by any existing down-town club. A gratifying list of members has already joined and there is every indication that the club will become what it was planned to be, a general rendezvous of all mechanical and allied interests.

New Publications

TREATISE ON HYDRAULICS. By W. C. Unwin. 327 5½x8½-in. pages, with 149 illustrations. Adam & Charles Black, London; The Macmillan Company, New York.

Any book from Professor Unwin's pen is, of course, entitled to respect and confidence, and the more so in the present case because his article on the same subject in the Encyclopedia Britannica has become accepted as a standard. The present volume is especially noteworthy because it recognizes the limitations of theoretical considerations in dealing with hydraulics, and will be found to be especially full in its incorporation of the enormous mass of accumulated data which exists on the subject. The work is thus strictly practical in the best sense, and it may be confidently recommended both as a treatise for students and as a book of reference for practicing engineers.

"LES AUTOMOBILES ET LEURS MOTEURS." By Lieut. de Chabot. 335 pages, 6½ x9¾ inches; 171 cuts in the text. E. Bernard, 1, Rue de Medicis, Paris. Price, 7 francs, 50.

The subjects touched upon in this book might readily be elaborated to fill several volumes; the author, however, has kept strictly to his intention of providing brief descriptive and explanatory matter for the benefit of both the *"chauffeur debutant"* and *"profane,"* the latter word having no reference to forcible language, but meaning as we would say, the "layman." It is not a book for the designer, containing little about proportioning parts and no formulas except a little about horsepower; it explains in an elementary manner, with the aid of outline illustrations which appear to be made from free-hand sketches, the various parts of an automobile. Gasolene engines of the various types, curves showing the piston pressures, stroke by stroke, of single- and multiple-cylinder engines, igniting and cooling arrangements, clutches, transmissions, differentials, tires and many other details are treated in a sketchy sort of manner. The subject of starting receives considerable attention, several starting devices being described, preference being given to that type which uses a pump and a special carbureter to force a charge into the cylinder of the engine. The danger of back-firing and means of avoiding it are explained at length. The Oldham and Cardan joints together occupy not over one page, and ball bearings are dismissed with an equal amount of space. There are two useful chapters treating of troubles and their remedies, in which a start is made at the front of the machine and the different places where difficulties may occur are taken up in turn. In this country it would scarcely be considered wise in a book of this sort to speak, as is done on page 12, of the "generatrix of the piston," in spite of the mathematical correctness of the term. The definition of a cam on page 10, though correct for the particular case referred to, is likely to give a tyro a wrong idea of the general meaning of the word: "The cam is a sort of eccentric."

Personal *

George F. Reed, Jr., has recently been appointed assistant mechanical superintendent of the Clark Thread Company, Newark, N. J.

F. Royal Pierce, long associated with the Brown & Sharpe Manufacturing Company as draftsman, is now practicing patent law in Easton, Penn.

C. E. Beck, assistant manager and engineer of the Sargent Engineering Company will succeed C. E. Sargent as manager who has resigned to accept position noted in another item.

Hunter Morrison, formerly connected with the organization of the Allis-Chalmers Company, has recently assumed the position of manager of the sales department of the Hill Clutch Company, Cleveland, Ohio.

Charles E. Sargent, who for the past seven years has been manager of the Sargent Engineering Company, Chicago, has resigned to accept the position of chief engineer and manager of the Gas Engine Department of the Wisconsin Engine Company, Corliss, Wis.

C. A. Dawley, formerly engineer of tests for the Ingersoll-Sergeant Drill Company, Easton, Penn., and who has engaged in practice in the field of compressed-air machinery, has been retained by the Ball & Wood Company, of New York and Elizabeth, N. J., in connection with their new line of air compressors.

W. F. Evans, for 10 years with the Studebaker Company, South Bend, Ind., and for the past year and a half master mechanic of the McCormick plant of the International Harvester Company, severed his connection with the latter firm the first of this year. Mr. Evans may take up a consulting practice.

*Items for this column are solicited.

New Tools and Machine Shop Appliances

Showing New Ideas in Machine Shop Equipment That Make It Possible To Do Better Work at a Reduced Cost

THE LATEST INFORMATION

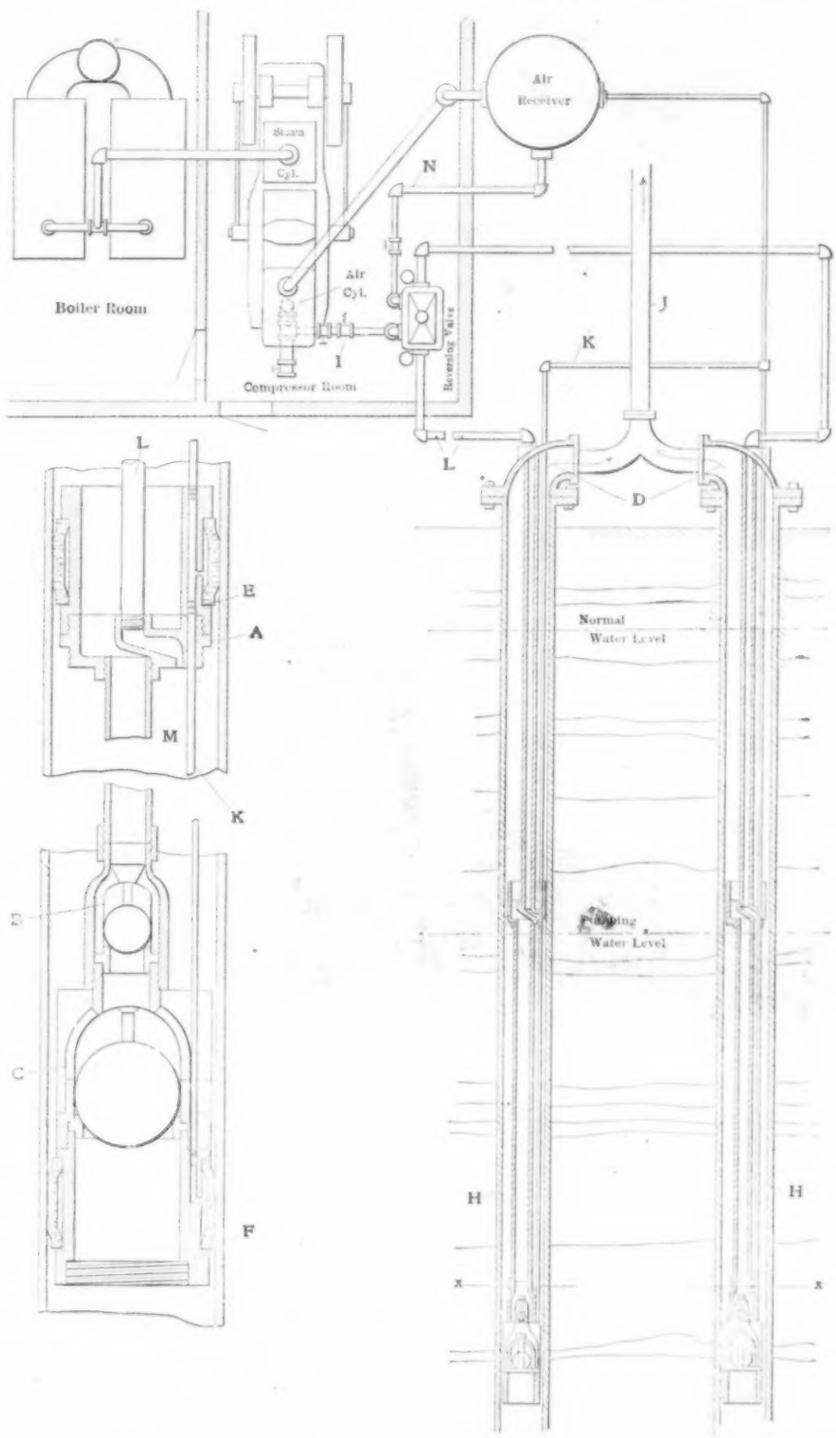
The Weber Subterranean Pump

The accompanying line engraving illustrates by diagram and a few details a recent development in air displacement pumps. It is known as the "Weber subterranean pump" and does not differ essentially from the common air displacement type except that the air exhausted from the well is returned to the air compressor instead of to the atmosphere, thus saving the work necessary to compress it to the pressure at which it enters the compressor. As illustrated, the pumping apparatus is shown installed in a well casing where the casing extends some distance below the water level and is made to serve the purpose of a tank or cylinder. Briefly naming some of the more important parts, *A* is the cap, *B* the upper ball case, *C* the lower ball case, *D* the elbow T leading to the discharge main, *E* the upper packing, *F* the lower packing and *I* a poppet relief valve.

In use air from the receiver of the compressor is transmitted through the pipe *K* to both the upper and lower packings. Thus the packing is forced against the inside of the well casing and seals the ends of the annular chamber between the cap *A* and the lower ball case *C*. This chamber is indicated by the letter *M*. Air is brought to this annular chamber through the pipe *L* and acts as a solid piston forcing the water through the inner discharge tube to the cap *A*, from which point the casing serves as a discharge main. When the water in this chamber is nearly expelled, the reversing valve operates and the pipe *L* and the chamber *M* instead of being under pressure are now under suction from the compressor. The air is removed and water enters the chamber *M* through the lower ball valve. If several wells are being pumped, while one-half of the number are under pressure the other half are under suction, and *vice versa*.

The reversing valve is operated by pressure when the water reaches the point *N*. No floats or time valves are used. In the compression suction line and between the compressor and the reversing valve is the poppet relief valve *I*. Its purpose is to admit air to the compressor suction in case through leakage, or other cause, there is an insufficient supply of air in the wells. The connection between the air receiver and the reversing valve is indicated at *N*. Where several wells are pumped, it is convenient to bring their discharges into a single main, as shown at *J*. Under normal conditions the ball valves will operate every 20 or 30 seconds. They are provided with adjustable seats.

For conditions where the well casing does not extend below the water line an inner tube is used for the intake chamber, and the packings are dispensed with. A recent capacity test on an 8-inch well



WEBER SUBTERRANEAN PUMP INSTALLED IN WELL CASING

180 feet deep showed a yield of 240 gallons of water per minute. This pump is built by the George H. Samson Company, of Boston, Mass.

A Universal Edge-tool Grinder

The illustrations show a machine designed for patternmakers but well adapted for use in other wood-working shops.

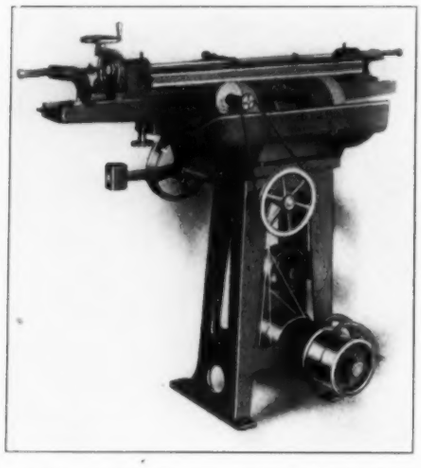


FIG. 1. WITH LONG KNIFE-GRINDING ATTACHMENT IN PLACE

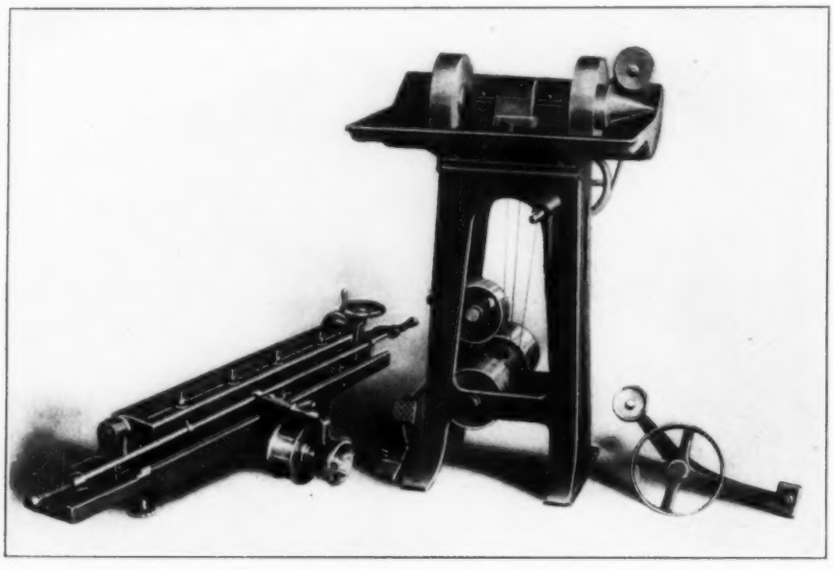


FIG. 2. WITH KNIFE-GRINDING ATTACHMENT REMOVED

Instead of having ordinary emery wheels the machine is equipped with coarse and fine grained oilstones. On the end of the main spindle a grinding cone is mounted for sharpening patternmakers' gouges. A small wheel at the back provides for light grinding.

The wheel arbor is driven from a driving shaft below, at right angles, by a quarter-twist belt running over an idler pulley, which serves to take up the stretch in the belt. This permits the driving pulley to be put on the back of the grinder, thus keeping the driving belt out of the way for grinding and can be belted from above or below.

An attachment for grinding long knives, which is fully automatic in operation, goes with the machine. It is shown in position in Fig. 1. The attachment is easily and quickly removed without taking out a single bolt. As long knives are seldom ground more than once or twice a month, the attachment can be set aside and the machine used for general sharpening of all kinds of tools. The machine is shown with this attachment removed in Fig. 2.

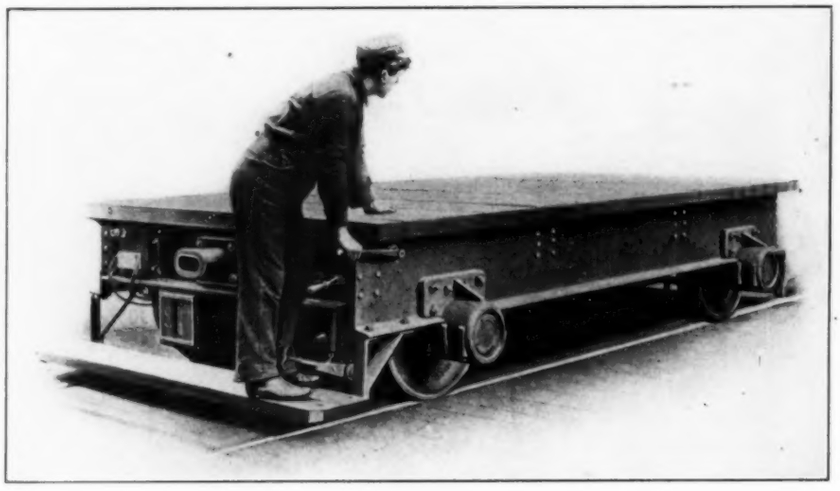
In operation the oilstone wheels are lubricated with kerosene oil.

This machine is made by Mummert, Wolf & Dixon Company, Hanover, Penn.

An Auto-truck for Industrial Railways

The illustration shows an auto-truck equipped with storage batteries for supplying current to the motor. The frame is of steel and is carried on four wheels, the journals of which run in roller bearings. The motor or motors are carried on the axle or axles, as the case may be, similar to street-car practice. A spring-suspended cradle of angle iron carries the battery trays.

At the operating end of the truck are mounted the controller, brake, charging receptacle, cut-out switch and volt-meter. A step and draw-bar head are provided at each end. All the machinery is below the top of the frame, but readily accessible.



AN AUTO-TRUCK FOR INDUSTRIAL RAILWAYS

During a six months' test of the standard 10-ton truck herewith illustrated, the power required to charge the battery in regular and heavy shop service was accurately metered. It averaged 63 kilowatt hours per month. The work done was recorded and averaged practically 700-ton miles per month, the loads running from a few hundred pounds to fifteen tons.

Standard trucks are made for six different gages, namely, 18, 21½, 24, 30 and 36 inches, and 4 feet 8½ inches. For track systems provided with turn tables, they are made with rigid trucks. Where tracks are installed with curves, the trucks for all gages up to 36 inches are provided with swiveled front axle, permitting free operation on curves as low as 12 feet in radius.

These trucks are made by the Westinghouse Machine Company, East Pittsburg, Pennsylvania.

Casting Nuts in Cast Metal

B. F. Barnes Company, of Rockford, Ill., has recently obtained a patent upon a device for placing a tapped nut in a cone.

Fig. 1 shows the core box for a pulley casting and the method of placing and holding the nut in position ready for the core to be rammed up around it.

Fig. 2 shows the pulley casting complete with the threaded nut cast in it and a set screw inserted.

This device does away with the neces-

sity of drilling through the rim of the casting and into the hub, and also the tapping operation in the hub. Where the pulley is of large diameter, taps are frequently broken in performing the tapping operation. This device is applicable to a great

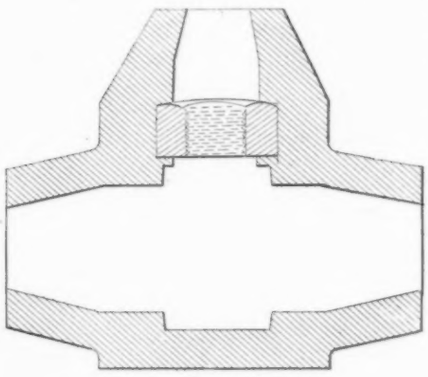


FIG. 1. CORE BOX WITH NUT IN PLACE

FIG. 2. PULLEY WITH NUT CAST IN

many castings, such as cone pulleys, sheaves, hangers and even larger castings.

The nut is held securely in the core box, insuring its being accurately placed in position in the core. The core material protects the thread from being injured by the hot metal.

Machinery used in the henequen industry throughout Yucatan is now purchased principally from the United States, the preference for American machinery over English, formerly used here, having shown a steady growth for some years past. Yucatan affords a good market for rails for portable plantation railways, which are now furnished almost wholly by European manufacturers. The principal imports of Yucatan from the United States are machinery, barbed wire, hardware, cattle, Indian corn, canned goods, druggists' supplies, ready-made clothing, and boots and shoes. A certain amount of hardware is annually furnished by Germany. Cotton textiles of domestic manufacture are purchased from neighboring Mexican States, and ribbons from France.

Measurement of V-Tools

By Harry F. Atkins

The accompanying table of angle measurements should prove of great convenience to toolmakers generally, and to all whose duty it is to make tools for cutting angles or to make with any degree of accuracy the gages for these tools. The table, however, will need a little explanation. Before attempting to explain, it may be well to give two illustrations of the kind of problem it is designed to overcome.

1. Example: A tool is required to cut an Acme screw thread. That means that it is required of a given angle with a point of a given width. The tool is ground to the angle required, after which the table makes it easy to measure the width of the tool point. Anyone who has tried to measure the point of a V-tool with a micrometer in the ordinary way knows that it takes considerable skill and time, and leaves behind considerable doubt as to the accuracy of the measurement after all. It is this doubt that is dissolved by the method of measurement recommended, not to mention a great gain in time.

2. Example: A tool is required to cut an accurate Whitworth thread. After grinding the tool to the required angle, the table makes it possible actually to measure the amount ground from the point in spite of the rounded form.

Of course both these difficulties and many others can be solved with gages; but even in well equipped shops such problems often have to be handled by measurement, especially in tool rooms.

The principle here adopted is that, on account of the difficulty and in some cases the impossibility of measuring the tool at

Degrees.	$\frac{\tan. \frac{\theta}{2}}{8}$	Degrees.	$\frac{\tan. \frac{\theta}{2}}{8}$	Degrees.	$\frac{\tan. \frac{\theta}{2}}{8}$
1	0.0011	31	0.0346	61	0.0736
2	0.0022	32	0.0358	62	0.0751
3	0.0033	33	0.0370	63	0.0766
4	0.0044	34	0.0382	64	0.0781
5	0.0055	35	0.0394	65	0.0796
6	0.0066	36	0.0406	66	0.0811
7	0.0077	37	0.0418	67	0.0827
8	0.0088	38	0.0430	68	0.0843
9	0.0099	39	0.0442	69	0.0859
10	0.0110	40	0.0454	70	0.0875
11	0.0121	41	0.0466	71	0.0891
12	0.0132	42	0.0489	72	0.0908
13	0.0143	43	0.0492	73	0.0925
14	0.0154	44	0.0505	74	0.0942
15	0.0165	45	0.0518	75	0.0959
16	0.0176	46	0.0531	76	0.0976
17	0.0187	47	0.0544	77	0.0994
18	0.0198	48	0.0557	78	0.1012
19	0.0209	49	0.0570	79	0.1030
20	0.0220	50	0.0583	80	0.1048
21	0.0231	51	0.0596	81	0.1067
22	0.0242	52	0.0609	82	0.1086
23	0.0253	53	0.0623	83	0.1105
24	0.0264	54	0.0637	84	0.1125
25	0.0275	55	0.0651	85	0.1145
26	0.0286	56	0.0665	86	0.1165
27	0.0298	57	0.0679	87	0.1186
28	0.0310	58	0.0693	88	0.1207
29	0.0322	59	0.0707	89	0.1228
30	0.0334	60	0.0721	90	0.1250

TABLE FOR V-TOOL ANGLE MEASUREMENTS.

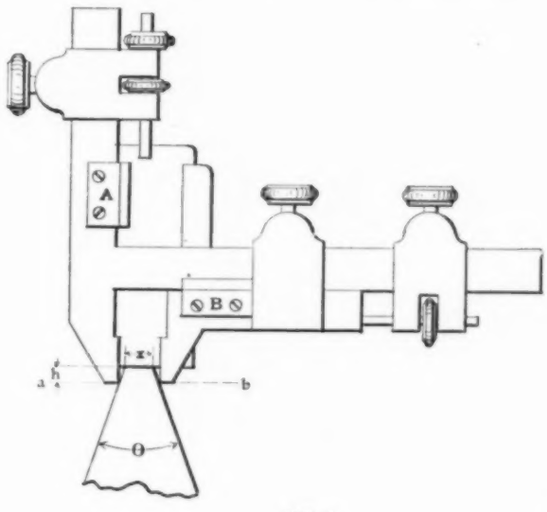


FIG. 1

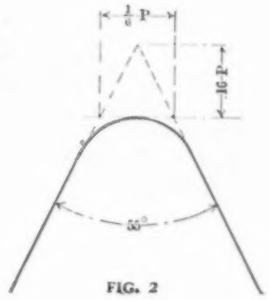


FIG. 2

MEASURING THREAD TOOLS

its point, the measurement is taken on the angle of the tool at a given distance from the point. In this case the true measurement will be less than the actual measurement by an amount equal to twice the tangent of half of the angle multiplied by the distance of the line of measurement from the point.

For making the measurement the Brown & Sharpe gear-tooth caliper serves very well and will be found in most shops. Fig. 1 shows this tool in position for measuring. The depth vernier A is set to a given depth h, and the measurement is taken by means of the vernier B. The width of the tool point x is equal to the measurement on the line $a\,b$ less $2h\left(tan.\frac{\Theta}{2}\right)$. To use the table, h is always taken to be 1/16 inch, which is found to be a convenient depth for most work. If a greater depth is required, all that is necessary is to multiply the figures given by the ratio of the required depth to 1/16 inch. For instance, if the depth is required to be ⅛ inch, the figures given are multiplied by 2. In the great majority of cases 1/16 will be found a suitable value for h, when to find the width of the point x it is merely necessary to deduct the value of $\frac{tan.\frac{\Theta}{2}}{8}$ for the angle required, which can be obtained at a glance from the table.

At first sight the necessity of referring to the table appears somewhat clumsy, but in practice it will be found that the very few angles that are generally used will soon fix their constants on the memory. Indeed, since the angle of 29 degrees has become so generally adopted both for worm and screw threads as well as tooth gearing, this angle (the Acme standard), with its constant 0.032, will be more used than any other and is very easily remembered.

Some will prefer to employ a table of natural tangents, which they use for other purposes as well; the extra calculation that is required not being by any means laborious. The table given, however, reduces the problem at once to plain figures.

In the case of the Sellers or United States standard thread, the point of the tool should be one-eighth of the pitch of the screw, while in the Whitworth standard the point of the tool would be one-sixth of the pitch if it were not rounded (see Fig. 2). By using these figures in combination with the table, it can be determined when sufficient has been ground from the point of the tool.

The table is called "Table for Angle Measurements," because if a sharp angle, that is, one without the point ground away, is measured as above, this measurement, by reference to the table, will give the angle direct.

A High-speed Ball-bearing Drill Press

The half-tones, Figs. 1 and 2, show the general appearance of a high-speed ball-bearing drill press designed to drive high-speed drills up to and including ¾ inch diameter to their full capacity.

The spindle driving pulley P, Figs. 3 and 4, is mounted on a stub Q which is babbitted into the frame R of the drill press, shown best in Fig. 3. The pulley P has two steps and is hung on ball bearings at top and bottom. The races A and B are steel, hardened and ground. The races A are adjusted by means of the threaded cast-iron ring C which is split where it is tapped to receive the tapered expanding screw D. The pulley P drives the spindle through a floating driving flange, shown in Fig. 4, so that at no time does the pulley P exert any side pull on the spindle. The cone pulley P, is counterbored at $F\,F$ and hardened steel driving bars are inserted at $G\,G$. The driving flange H has a feather I which is a sliding fit in the spline in the spindle. It is also provided with two hardened steel rollers J. These are smaller than the counterbored holes $F\,F$ in the pulley P in which they are situated when the press is assembled. When the pulley P rotates, it forces the hardened-steel driving bars G against the hardened-steel driving rollers J and the driving flange H rotates, driving the spindle through the spline I. There is sufficient play in the holes F, so that, should the bearings upon which the pulley P is hung become so worn that the pulley is eccentric to the spindle, the pulley cannot exert any side pull on the spindle.

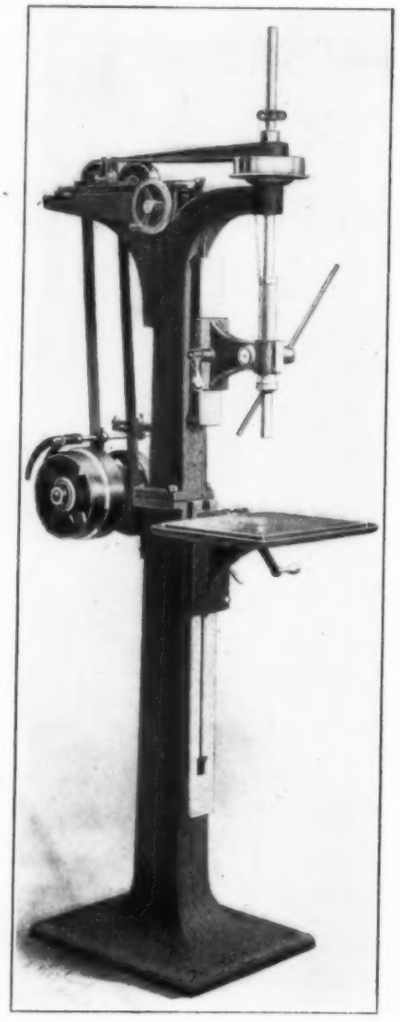


FIG. 1. BELT TIGHTENER

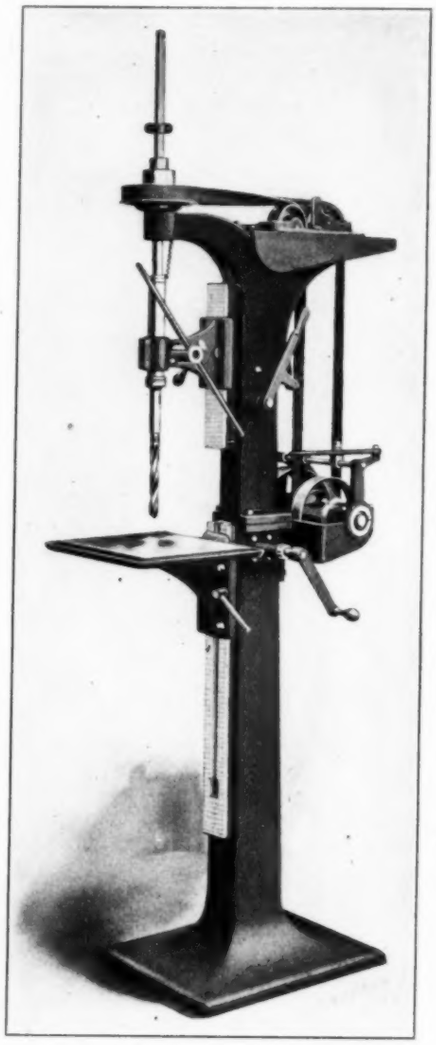


FIG. 2. TOGGLE FOR RAISING IDLER BRACKET

It is well known that a quarter-turn belt drive can be led *off* a pulley at almost any angle without trouble but that the belt must be led *on* to a pulley by having the pulley at the correct angle. The angle at which the axis of the front idler A, Fig. 5, of the drill press, is set is fixed with relation to the axis of the spindle. The belt leads off it to the cone pulley. It is also fixed in the same respect to the

axis of the countershaft, but it can be raised or lowered so as to bring the upper part of the face of *A* in line with the small or large step of the cone pulley. Both the idlers *A* and *B* are mounted on the bracket *C* which slides vertically on the main frame of the machine so as to bring the idler pulleys in correct alinement for the large or small step on the

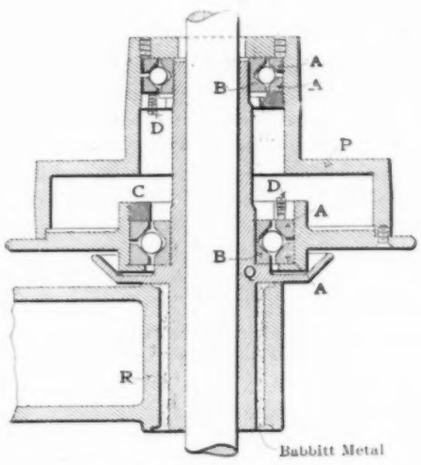
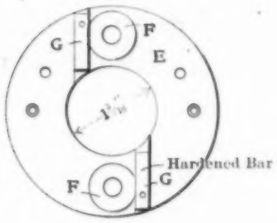
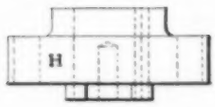
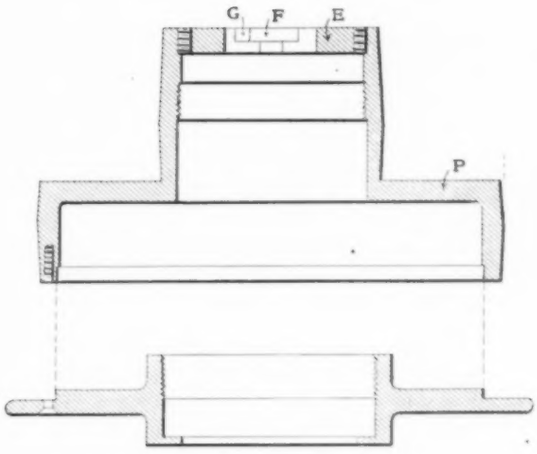


FIG. 3. DETAIL OF SPINDLE CONE PULLEY







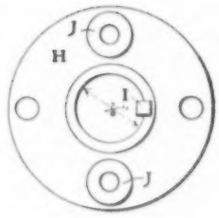
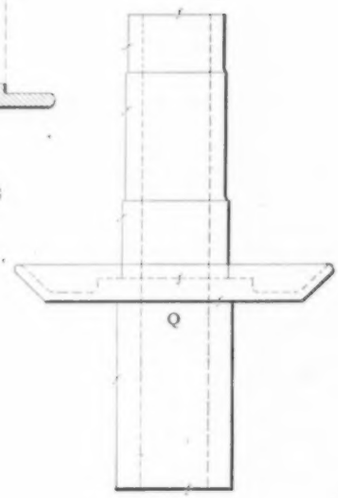
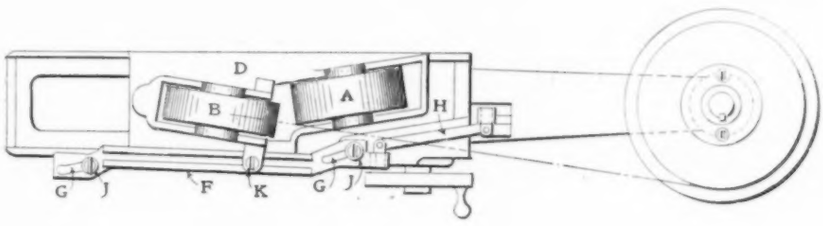


FIG. 4. SPINDLE PULLEY DRIVING FLANGE AND QUILL





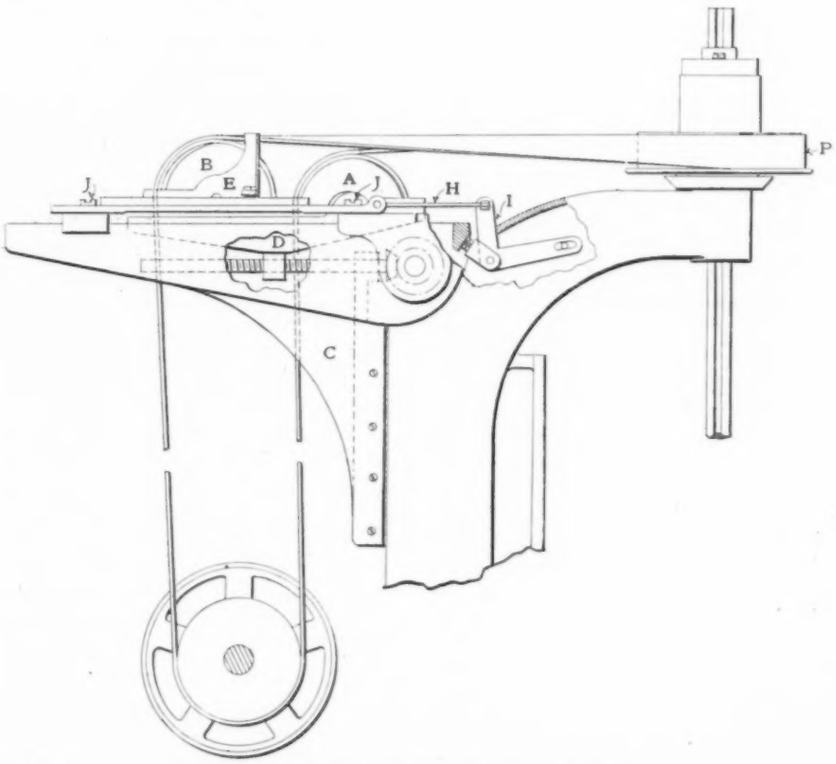


FIG. 5. DETAILS OF BELT ADJUSTMENT

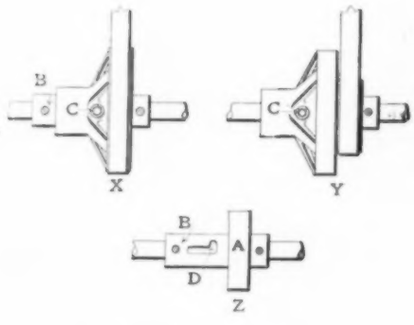


FIG. 6. THE DRIVING PULLEYS

spindle cone pulley. This raising and lowering is accomplished from the front of the machine by means of a toggle link actuated by a lever, shown in Fig. 2 at the side of the frame almost in line with the sliding head. The action of the toggle is very easy, and the lever coming in contact with a pin, the bracket is self locking in either position.

On top of the bracket *C* there is an idler carrier *D* in which are the bearings for the idler *A*. The bearings for the rear idler *B* are secured in a separate

bracket *E* pivoted on *D*. At the side of the bracket *E* is a metal piece *F* having two cam slots *G* in it, one at either end. This piece *F* is slideably secured by the shoulder screws *J* through the cam slots *G* to the bracket *C*. It is also connected by a link *H* to one end of the bell crank *I*. The other end of the bell crank is slotted and a pin passes through the slot and into the drill-press body. The fulcrum of the bell crank is screwed into the bracket *C*. In the piece *F* is a long straight slot. The point of the screw *K* in the bracket *E* projects into the straight slot in *F*, and controls the position of the bracket *E* in which the rear idler *B* has its bearings.

It is obvious that if the bracket *C* be raised so as to bring the upper part of the face of the idler *A* in line with the small step of the cone, the piece *F* will be moved forward, the cam slots will throw the piece *F* and the rear idler *B* will be swung into line with the face of the small pulley.

In Figs. 1 and 5 there is a small hand wheel shown just in front of the idlers; this actuates the belt tightening through bevel gears, screw and nut, forcing the slide *D* which carries both idlers, back on the bracket *C*. Both idlers traveling back to tighten the belt preserves the same belt contact on the driving pulley of the countershaft, with the idlers in any position on the bracket *C*. As a screw is used to tighten the belt this feature is self locking.

The arrangement of the pulleys on the countershaft is shown in Fig. 6. At *X* the belt is shown on the large pulley, at *Y* the belt is shown on the small pulley. At *Z* is shown the bayonet lock *D* for keeping the large pulley in position on the hub of the small pulley, in line with the idlers. The small pulley *A* has a long hub *B* in which is a milled slot *D*. The large pulley is a sliding fit on this hub and has a set-screw *C* the point of which, devoid of threads, is a sliding fit in the slot *D*; the pull of the belt will keep the pulley in driving position, i.e., with the small pulley telescoped inside it, and when the belt is on the small pulley as at *Y*, Fig. 5, there is no tendency on the part of the large pulley, to move.

The machine is so designed that all adjustments are made from the working position of the operator. This feature, besides its convenience, makes it possible to install a series of machines placed back to back or against a wall.

All bearings are ball bearings. The machine runs with little friction. In a recent test, a ¾-inch hole was drilled through 1¼ inches of cast iron in seven seconds; the drill was of course made of high-speed steel.

These drill presses are built with either single or multiple spindles in two sizes, 16 and 19 inches swing, by Chas. G. Allen Company, Barre, Mass.

Foundry Cores, Core Sand and Core-making Machinery *

By Geo. H. Wadsworth†

A common fallacy among foundrymen is to think that one core mixture will suit a wide range of foundry conditions.

Now the facts of the case are that in a single foundry it may be profitable to have a number of separate and distinct core mixtures, using entirely different grades of core sand and binders. From this it is clear that each class of cores must receive separate consideration.

A core must be porous so as to provide a ready passage for the gases as they escape when the metal is being poured about the core. At the same time it must have sufficient strength to resist the wash of the metal. The composition of the core must be such that it will burn brittle when exposed to the metal, so as to crush as the metal shrinks about it, thus relieving the casting from unnecessary strains. This is especially true in the case of cores used for brass and aluminum castings. The core must also burn brittle enough so that it will clean from the castings easily, and in some cases it is important that the surface be of such a nature that it will give a perfectly true, clean, parallel hole free from rough scale. The core mixture must also be cheap.

One great objection to many core mixtures is that they contain material which, when exposed to the heat of the metal, gives off gases which are injurious.

In all core mixtures which come under the scope of this paper, sharp sand forms the principal portion of the body of the core; the remainder of the material being known as the bond. Bonds may be divided into two classes, natural and artificial. The natural bonds practically all belong to the clay class; that is, they are some alumina product. Sand frequently contains a certain amount of alumina or clay, which is frequently known as loam. For some classes of work this forms an efficient core bond, but in the case of brass, aluminum or gray-iron work, it often burns so hard during casting as to make it very difficult to remove the core when the clay is present in large quantities. Some of the modern dry core compounds have pitch for a base, and they also contain powdered coke or other material to cut down the sticky nature of the pitch. Such binders will be found exceedingly useful in the case of large cores, but for machine-made cores dry binders have not proved very successful.

The large cores are rarely wanted in such quantity as to warrant the use of a machine in their production, while the very small cores and particularly those which are of irregular shape, require special treatment, and when wanted in quantities must be made in metal boxes and frequently provided with carefully fitted core wires.

The mixture for these very small cores should be made of good sharp silica sand and some very good strong core binder. The expense per pound of mixture is a consideration which drops out of sight entirely in comparison with the necessity for having strong accurate cores which can be handled and which will not fail when the metal strikes them.

We now turn to the great class of cores known as machine-made cores. The first machine developed was one to produce cylindrical cores from 1 inch to 1½ inches in diameter. Dies were afterward fitted to this same machine which enabled it to make cores to 2¼ inches in diameter and down to ⅜ inch. At first it was supposed that only cylindrical cores could be made, on account of the fact that it was observed that the core as it came from the die always rotated. Later, however, an attempt was made to turn out square cores, and as this proved successful, many other irregular shapes of prismatic cross-section have been successfully turned out on the standard machine. The second machine turned out cores up to 5 inches in diameter, and the design was later changed so as to make cores up to 7 inches in diameter. Later there came an inquiry for a machine capable of turning out slab cores, and to meet this demand the multiple-spindle slabmore machine was designed.

The next step was naturally to use the multiple spindles for turning out several cores in parallel. The next demand received was for one which should turn out small square cores which should not vary more than 2/1000 of an inch above or below the required size; in other words, should be held within 4/1000 inch as the total limit of error.

To accomplish this the multiple-spindle principle was used, special dies designed for the purpose and the cores turned out very satisfactory. One point worthy of note is that these core machines could never have been designed and made successful without keeping in very close touch with the work which they were doing.

Core-machine mixtures are an important part of the machine core business. They vary greatly, depending upon the size of the core used and the available material. As in all core mixtures, sharp sand is the base of the mixture. Flour has also been found to be the best binder for most core sands, but it has also been found advantageous to add a small quantity of boiled linseed oil to the mixture.

In case of very small cores, a relatively larger amount of oil and flour is required, and the amount of water used in tempering the mixture must be kept as low as

*Abstract of address delivered before the Chicago Foundry Foremen, Dec. 18, 1907.

†Superintendent of the Falls Rivet and Machine Company, Cuyahoga Falls, Ohio.

possible, as too much water will cause the sand to pack in the dies and block the machine.

As something to work on in beginning to experiment, the following mixtures are recommended:

Mixture for gray iron for cores ⅜ to 2⅛ inches—12 quarts silica, lake or clear sharp sand, free from loam or clay; 2 quarts flour, ½ pint boiled linseed oil.

For cores 2¼ to 7 inches—15 quarts sharp sand, 3 quarts Zanesville or a loam sand, 3 pints flour, ½ pint boiled linseed oil.

Mixture for brass and aluminum castings—4 quarts silica or good sharp sand, 2 quarts brass molding sand, ¼ pint boiled linseed oil. The more water the mixture will carry the harder and stronger the core will be when baked.

No. 1 core mixture for steel casting ½ to 2¼ inches; this mixture is used without grinding—6 quarts silica sand, 1 quart flour, ¼ pint boiled linseed oil.

Cores 2½ inches and above—18 quarts silica sand, 3 quarts fire clay, 1¼ quarts flour, ½ pint boiled linseed oil.

These steel mixtures must be very thoroughly mixed by hand when a more suitable way is not advisable.

The fire clay can be increased or decreased according to the hardness of the core produced by the particular sand in use.

No. 2 mixture for steel castings ½ to 2¼ inches; this mixture should be ground thoroughly in a mill—6 quarts silica sand, ¼ pint boiled linseed oil, 1½ pints flour.

Cores 2½ inches and over—6 quarts silica sand, 3 pints flour, ¼ pint boiled linseed oil.

We know that in practice many foundries have departed a long way from these mixtures, but believe that the formulas given above will serve as a guide in working out core-machine mixtures.

In some cases all cored holes are bored in the machine shop. Under these circumstances, a perfectly smooth hole is not necessary. It is only essential that the core leave the casting readily, and that it does not leave a hard scale in the hole. This may usually be accomplished by the use of a good grade of sand and a moderate of flour and oil in the binder.

At this point, however, it may be well to state that flour as sold to the foundrymen is not a definite compound, and that many so-called core flours are loaded with plaster of paris, ground gypsum, etc. Now these adulterants may or may not have an effect on the scale which the hot iron will form when it strikes the core, but they certainly do have an effect on the bonding properties of the flour, and a few dollars thrown off the price per ton on these heavily loaded flours may be far more than offset by the reduction in the bonding power of the material; hence, in figuring your core mixtures it is well to see that you are really using flour.

With the advent of the core machine many agricultural implement manufacturers have discovered that machine-made cores produce true, round, parallel holes which will vary less than one one-hundredth of an inch in diameter, and that by the use of suitable blacking on the cores these holes can be cleaned perfectly, so that shafts may be safely run in bearings which are cored to receive them and are given no subsequent machining. In like manner, wheels are run on axles without machine work.

In experimenting the black loam from a celery swamp was tried in core mixtures with sharp sand, and it was found that when this was dried and ground, tempered and put through a core machine, it produced a core which left the work readily and gave a remarkably clean hole. The vegetable mixture contained in it shrinks in the core oven and gives ample vent to the core, and it burns out in the casting, causing the core to be very rotten indeed. Great care must be taken in baking such cores as they will burn very easily.

In our own foundry the mixtures were formerly made by hand from a mixture of 50 per cent. sharp sand and 50 per cent. new No. 4 Zanesville, which is a loam sand with two parts of compound. We decided that if the old core sand could be passed through a suitable mill that the bond could be made much more efficient and the old sand used over, and to our surprise we find that we can now use 90 per cent. of old sand in the mixture and that we have been able to cut out the more expensive sand that we formerly used in our core mixtures, so that at present we have 90 per cent. old sand and 10 per cent. new sharp sand from a local sand bank.

Formerly we used two parts to the hundred of dry core compound; now we use but one part to the hundred, and a little molasses water. That is to say, it has been found that the dry core compound in the old core prints and also in the interior of the larger cores, is still active and when thoroughly incorporated with the new mixture by grinding in the mill, it becomes effective when the core is baked.

The subject of core mixtures would not be complete without some treatment of the baking of cores. In the baking of an ordinary core two processes take place. First the water used as a temporary bond is expelled as vapor, and second, by the application of a higher heat, the permanent bond is made effective. The natural or clay bonds are made effective by drying, for at the temperature of an ordinary core oven these bonds do not vitrify.

Such bonds as linseed oil, core oil, resin, pitch, etc., become effective by first being made more fluid under the influence of heat so that they spread rapidly through the sand grains, and second, by being partially oxidized or changed chemically so that as the core cools it hardens.

This is particularly true in the case of linseed oil or corn oil. Where flour is used as a binder the hardening process is essentially the same as the making of bread; in other words, through the action of the heat and the expulsion of the moisture, the gluten in the flour is made effective.

An efficient core oven should have the largest possible amount of the space in the oven occupied by cores. To accomplish this in the case of machine-made cores requires a rectangular oven with straight drawers. The drawers should be so designed that the expansion or contraction of the oven will not cause them to bind, and at the same time the drawers should be so arranged that the front of the oven is closed no matter whether the drawers are pushed back into the oven in the baking position or drawn out into the charging position.

To secure these advantages the oven exhibited here tonight has been designed and the fuel used can be either coke, coal, gas or fuel oil.

Business Items

The business heretofore conducted by W. E. Shipley, Philadelphia, has been incorporated under the name of W. E. Shipley Machinery Company.

The E. H. Mumford Company has acquired all the patent rights, molding machines and equipment of Ph. Bonvillain & E. Ronceray in the United States and has added to its molding machine line these machines and pattern processes. The offices of the E. H. Mumford Company will be removed from Seventeenth and Callowhill streets, its present location, to 1315 Race street, Philadelphia, where the French machines have been, for some months, installed as a working exhibit.

Manufacturers

D. J. Landers, Springfield, Mo., will erect a two-story brick planing mill.

A new dye house will be erected for the Wood Worsted Mills, Lawrence, Mass.

The Shaw Land and Timber Company, Ivor, Va., will install new machinery.

It is reported that the Big Four Railroad will enlarge the shops at Bellefontaine, Ohio.

A. Rhodes & Sons, Gibsland, La., will rebuild sawmill and cotton gin recently burned.

The St. Clair Gas and Electric Company, East St. Louis, Ill., will build a new gas plant.

The Blackstone (Va.) Hand-Shaved Handle Company will rebuild its burned plant on a larger scale.

The Billingham Chain Works, Trenton, N. J., is rebuilding its plant recently destroyed by fire.

The Conant & Donelson Company, Greenfield, Mass., manufacturing taps and dies, will build a plant.

The M. B. Farrin Lumber Company, Cincinnati, Ohio, will expend $75,000 in additions to the plant.

The Greenlee Bros. Company, Rockford, Ill., building special woodworking machinery, is enlarging its plant.

Want Advertisements

Rate 25 cents a line for each insertion. About six words make a line. No advertisements abbreviated. Copy should be sent to reach us not later than Friday for the ensuing week's issue. Answers addressed to our care will be forwarded. Applicants may specify names to which their replies are not to be forwarded, but replies will not be returned. If not forwarded, they will be destroyed without notice. No information given by us regarding any advertiser using box number. Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Only bona fide advertisements inserted under this heading. No advertising accepted from any agency, association or individual charging a fee for "registration," or a commission on wages of successful applicants for situations.

Miscellaneous Wants

Caliper list free. E. G. Smith Co., Columbia, Pa.

If you use small gears in large quantities, write Berry and Parker, Erie, Pa.

We buy or pay royalty for good patented machine or tool. Box 282, AMER. MACHINIST.

Hand power bending tools, labor-saving, money-making. Estep & Dolan, Sandwich, Ill.

Light, fine machinery to order; models and electrical work specialty. E. O. Chase, Newark, N. J.

Want to rent a small machine shop equipped in Brooklyn. Address "Shop," AMERICAN MACHINIST.

Special machinery designed and built; duplicate parts, tools, jigs and dies. The Wade Machinery Co., 133 Oliver St., Boston.

A second hand planer, lathe, drill press, milling machine; state size and price. Address "K. & P.," AMERICAN MACHINIST.

Special machinery accurately built. Screw machine and turret lathe work solicited. Robert J. Emory & Co., Newark, N. J.

Mechanics, write for our special offer of how to get a set of wrenches free. Bullard Automatic Wrench Co., Providence, R. I.

Automatic machinery designed, ideas developed, work done by the hour at your place or mine. Box 751, AMERICAN MACHINIST.

Automatic machinery designed; special purpose machines; working drawings. C. W. Pitman, 3519 Frankford Ave., Philadelphia, Pa.

Designer of automatic and special machinery; mechanical drawings of any kind made. John G. Wittum, M. E., 93 Sherman Ave., Newark, N. J.

Factory foremen and superintendents cannot afford to miss our slide rule course. The Mechanics Correspondence School, Box 455, Lockport, N. Y.

Wanted—To correspond with individual or firm with a view to establishing agency for Electric Cranes in New York and Philadelphia territory. Box 730, AMER. MACHINIST.

Have you any copies of December 12 and 19 issues of the AMERICAN MACHINIST? We will give fifteen cents for every copy that we can get. AMERICAN MACHINIST, 505 Pearl St., New York.

Wanted—For greater New York and New England States; sales agency for any meritorious tool or article saleable to machine shop trade, which we are calling on direct. Box 752, AMERICAN MACHINIST.

For Minneapolis and St. Paul territory, manufacturer's agency for any meritorious article or machine, saleable to machine shop trade; we can sell it if it's "right." Roy Machinery Co., Minneapolis, Minn.

A large English firm of machine-tool importers having showrooms and offices in Great Britain, France, Italy and Japan, is wanting good agencies for machine tools of all kinds. Apply Box 189, AMER. MACHINIST.

Machinery built to order and by contract; special parts made; gear cutting, automobile and pattern work, punch press and screw machine work, tools, dies, etc. Blair Tool and Machine Works, West and Morris Sts., New York City.

Wanted—Machine shop to take possession of best new constructed stationary marine oil engines of future; constructor; German; 20 years' experience; will take inspection about work, drawings, patterns; ready to begin immediately. Box 757, AMER. MACH.

Special machinery and duplicate machine parts built to order; tools, jigs and experimental work; complete modern equipment. MacCordy Mfg. Co., Amsterdam, N. Y.

The annual meeting of the stockholders of the Hill Publishing Company, for the election of directors for the ensuing year and for the transaction of such other business as may properly come before the meeting, will be held at the office of the company, in the Hallenbeck building, 497-505 Pearl street, Borough of Manhattan, New York City, N. Y., on Tuesday, January 28, 1908, at 12 o'clock noon. Dated, New York City, December 17th, 1907. Robert McKean, Secretary.

We want to purchase or handle the patents or designs for a line of machinists' tools or machine shop specialties; would prefer to take up some entirely new tools or a noticeably new design; we are willing to consider either the purchase of patent, manufacturing under royalty, or the introduction and selling of new tools, the manufacture of which is already started; we are located in New England and are experienced manufacturers and also salesmen of wide acquaintance and influence and wish to use this experience in bringing out a line of specialties. Address with full particulars. Box 725, AM. MACH.

Situations Wanted

Classification indicates present address of advertiser, nothing else.

CONNECTICUT

An up-to-date machinist and toomaker, 50 years old, desires a position as keeper of tool or stock room; understands good systems; have organized, equipped and been in charge of like departments. Address in first instance. Box 753, AMERICAN MACHINIST.

ILLINOIS

Assistant superintendent of a Connecticut factory wishes to locate in or near Chicago; three years in present position and five years previous experience in drafting room and machine shop; 32 years old; graduate of Yale; junior member A. S. M. E. Box 732, AMERICAN MACHINIST.

MASSACHUSETTS

Machine designer and draftsman; 7 years' shop, 8 drafting experience; best references; wishes position. Box 755, AMER. MACH.

Is your production slow and costly; try another superintendent more up to date, expert mechanic, executive, good organizer and systematizer; wide awake with long and varied experience as superintendent; light or medium manufacturing preferred. Address "Expert," AMERICAN MACHINIST.

NEW JERSEY

Ambitious man, 25, with 5 years' shop experience, 4 years as draftsman; fair technical education; wishes position with advancement. Box 761, AMERICAN MACHINIST.

I. C. S. student, (complete mechanical course) now working on final examination paper for diploma; practical machinist and toolmaker; wishes position as draftsman. Box 748, AMERICAN MACHINIST.

Mechanical engineer; 32; graduate of European university with 9 years' experience; is open for engagement Feb. 15; expert in calculating and designing modern centrifugal and turbine pumps; had employment with leading firms abroad and in this country; inventing and designing hydraulic machineries a specialty; reliable man, first-class references. Address "J. D.," AM. M.

NEW YORK

Mechanical draftsman wishes position. Address Box 758, AMERICAN MACHINIST.

Mechanical engineer; college graduate; one year shop, four years' drafting experience, wants position. Box 759, AMER. MACHINIST.

Mechanical draftsman; 6 years' experience on automatic machinery, pumping machinery, valves and automobiles, wants a position. Box 741, AMERICAN MACHINIST.

First-class tool designer; 30 years; college graduate; 10 years' practical and office experience; A-1 references; wants position. Box 760, AMERICAN MACHINIST.

Mechanical engineer, not a routine man, with 17 years' experience on light and heavy constructions, desires change; accustomed to heavy responsibilities, masses of detail; competent to direct technical, office and productive forces; fully posted on gas and oil engines and general industrial processes; possess numerous patents; am not particular about location. "Executive," AM. M.

OHIO

Electrical engineer, designer, direct current motors and generators for all purposes; a practical mechanic, and familiar with every detail of manufacture; first-class references. Box 723, AMERICAN MACHINIST.

Superintendent or general foreman by a first-class mechanic with experience in building high grade automatic screw machines, special machinery, tool and die work. Address "F. J. O.," 35 N. Philadelphia St., Dayton, Ohio.

WISCONSIN

General foreman or superintendent; 31; practical mechanic successful in producing first class work at satisfactory cost; am an organizer of best shop methods; am now employed as superintendent; best of references. Box 754, AMERICAN MACHINIST.

Help Wanted

Classification indicates present address of advertiser, nothing else.

CALIFORNIA

First-class toolsmith; must be able to temper taps, dies and expensive tools; permanent job at good wages for right man. Address, giving age, experience, nationality, etc. Box 750, AMERICAN MACHINIST.

CONNECTICUT

Wanted, representative in Boston and Philadelphia districts on commission basis by gray iron foundry making specialty of medium weight high grade castings; prefer man having established trade in noncompeting lines and who would have acquaintance with tool builders, etc. Address, giving full particulars, "Iron Founder," care AM. MACH.

ILLINOIS

Wanted—First-class machine shop foreman to take charge of small shop, building special machine work and repairing contractors' tools; location Chicago. Address Room 501, 135 Adams St., Chicago, Ill.

Wanted—Foreman of shop to manufacture pulleys, hangers, couplings, etc.; must be thoroughly familiar with all details of work; state experience and salary wanted. Address "Transmission," AMERICAN MACHINIST.

MASSACHUSETTS

Mechanical designer; a first-class mechanical designer with large experience in designing high-speed steam engines wanted for permanent position in New England States; state age, education, experience in detail and salary expected; only detailed applications will be considered. Box 749, AMER. MACH.

Wanted—A thoroughly competent manager or foreman to take charge of the machine department of a manufacturing concern in southern Massachusetts; must be thoroughly familiar with modern methods and modern machine tools and must be a good executive prepared to undertake the management of 100 to 150 men engaged in the construction of small machines, the manufacture and repair of dies and general repair work. Box 736, AMERICAN MACHINIST.

MICHIGAN

Wanted—An experienced general foreman or superintendent; must be a mechanic with good executive ability competent to take charge of gas engine works employing 50 to 75 men building large engine; must have good references; state age, experience and salary wanted from start for immediate acceptance. Box 756, AMERICAN MACHINIST.

NEW YORK

Wanted—An experienced draftsman of both mechanical and structural architectural drawing for a technical school; permenent position for first-class man. Apply by letter stating qualifications and experience in full, to Instruction Committee, P. O. Box 37, Station D, New York.

Wanted—Draftsman for leading place in drawing office of engineering and manufacturing concern; preferably one who has had mechanical training and conversant with shop practice; to inspect work in course of execution and detect irrational methods; good salary will be paid to man who can demonstrate ability; answer giving experience age, etc. Box 762, AMERICAN MACHINIST.

OHIO

Top notch foundry superintendent wanted at once for new machine-molding gray iron foundry; the various buildings and equipment just being completed; strictly up-to-date including continuous pouring; applicant must be temperate in habits, of good character, aggressive, and above all, a good executive; full knowledge of molding machines and best application of patterns thereto absolutely necessary; give full particulars, references, where employed at present, and state salary required; all communications treated confidentially; no cheap man need apply. Address The Cincinnati Milling Machine Co., Cincinnati, Ohio.

PENNSYLVANIA

Wanted—A first-class machinist for universal milling machine work; state experience. Stoever Foundry and Manufacturing Company, Myerstown, Penn.

Wanted—Machine shop foreman; one accustomed to steam engine work and general repairs; must be capable of handling 50 men and have usual qualifications. Shop is in the Pittsburg district. Box 729, AMER. MACH.

VERMONT

Want to get in touch with a number of

cost accountants, time, cost and factory clerks; give complete record. Address P. O. Box 713, Windsor, Vt.

FOREIGN

Wanted—First-class designer and draftsman from United States of America for modern tool and machinery; must be able to talk Norwegian or Swedish, and be well informed about modern tool building. "Progress," Verktoimaskinfabrik, Christiania, Norway.

For Sale

For Sale—Foundry, wood and iron machine shop; all equipped. Box 74, Albion, N. Y.

For Sale—Back copies American Machinist. J. Beasley, Metropolitan Bldg., Orange, N. J.

For Sale—Two pairs of Tabor steam engine indicators in good order, have been but little used. Address for full description and price. Box 727, AMERICAN MACHINIST.

For Sale—Ten volume library, covering completely the work of the engineer and machinist; good as new; cost $50; will sell for $15. Address "T. M. T.," Box 425, Chicago.

For Sale—Cyclopedia for modern shop practice, four volumes; bound in green morocco leather. Practically new; cost $18; will sell for $6. Address "L. N. O.," Box 425, Chicago, Ill.

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Bending Machinery, Plate

Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Toledo Machine & Tool Co., Toledo, Ohio.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.

Bending Machinery, Power

Boynton & Plummer, Worcester, Mass.
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.

Bending Tools, Hand

Estep & Dolan, Sandwich, Ill.
Wallace Supply Co., Chicago, Ill.

Blanks, Nut and Screw

Dyson & Sons, Jos., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Blocks, Chains

See Hoists, Hand.

Blocks, Die

Nicholson & Co., W. H., Wilkes-Barre, Pa.
Witteman Co., A. P., Phila., Pa.

Blowers

American Blower Co., Detroit, Mich.
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
General Electric Co., New York.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Roth Brothers & Co., Chicago, Ill.
Sturtevant Co., B. F., Hyde Park, Mass.

Blue Print Machines

General Electric Co., New York.
Revolute Machine Co., New York.

Blue Print Paper

Revolute Machine Co., New York.

Boilers

Struthers-Wells Co., Warren, Pa.

Bolt and Nut Machinery

Acme Machry. Co., Cleveland, O.
Boynton & Plummer, Worcester, Mass.
Brown Co., H. B., East Hampton, Conn.
Davis Machine Co., W. P., Rochester, N. Y.
Foote-Burt Co., Cleveland, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Landis Machine Co., Waynesboro, Pa.
Manning, Maxwell & Moore, Inc., New York.
Mummert, Wolf & Dixon Co., Hanover, Pa.
National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.
Prentiss Tool & Supply Co., New York.

Bolt and Nut Machinery —*Continued.*

Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Engineering Works, Ellwood City, Pa.
Vandyck Churchill Co., New York.
Waterbury Farrel Fdry. & Mach. Co., Waterbury, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Bolt Heads

Lang Co., G. R., Meadville, Pa.

Bolts, Coupling

Cleveland Cap Screw Co., Cleveland, O.
National-Acme Mfg. Co., Cleveland, O.

Bone for Case Hardening

Rogers & Hubbard Co., Middletown, Conn.

Books, Technical

American School of Correspondence, Chicago, Ill.
Henley Pub. Co., N. W., New York.
Hill Publishing Co., New York.
Piers, Frank, Phila., Pa.
Sames, Chas. M., Jersey City, N. J.

Boosters

Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sprague Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Boring and Drilling Machines, Horizontal

Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Betts Mach. Co., Wilmington, Del.
Binsse Mach. Co., Newark, N. J.
Boynton & Plummer, Worcester, Mass.
Detrick & Harvey Mach. Co., Wilmington, Del.
Fitchburg Machine Works, Fitchburg, Mass.
Fosdick Mach. Tool Co., Cin., O.
Gisholt Mach. Co., Madison, Wis.
Hill, Clarke & Co., Inc., Boston, Mass.
Lucas Mach. Tool Co., Cleveland, Ohio.
Manning, Maxwell & Moore, Inc., New York.
McCabe, J. J., New York.
Motch & Merryweather Machinery Co., Cleveland, O.
Newton Mach. Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill .
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Whitcomb - Blaisdell Mach. Tool Co., Worcester, Mass.

Boring and Turning Mills, Vertical

American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Baush Mach. Tool Co., Springfield, Mass.
Betts Mach. Co., Wilmington, Del.
Bullard Mach. Tool Co., Bridgeport, Conn.
Colburn Mach. Tool Co., Franklin, Pa.
Gisholt Mach. Co., Madison, Wis.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
McCabe, J. J., New York.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.

Boring Tools

Armstrong Bros. Tool Co., Chicago, Ill.

Boxes, Tote

Cleveland Wire Spring Co., Cleveland, O.
Lyon Metallic Mfg. Co., Aurora, Ill.

Box Tools

Bardons & Oliver, Cleveland, O.

Brackets, Lamp

Standard Welding Co., Cleveland, Ohio.

Brazing

Industrial Oxygen Co., New York.
Reinforced Brazing and Machine Co., Pittsburg, Pa.

Broaching Machines

Harrington, Son & Co., Edwin, Philadelphia, Pa.
Lapointe Mach. Tool Co., Hudson, Mass.

Bulldozers

National Machinery Co., Tiffin, O.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.

Cabinets, Tool

Armstrong Bros. Tool Co., Chicago, Ill.
Hammacher, Schlemmer & Co., New York.
Lyon Metallic Mfg. Co., Aurora, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.

Calipers

Athol Mach. Co., Athol, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Sawyer Tool Mfg. Co., Fitchburg, Mass.
Slocomb Co., J. T., Providence, R. I.
Starrett Co., L. S., Athol, Mass.

Cams

Bilgram, Hugo, Phila., Pa.
Boston Gear Works, Norfolk Downs, Mass.

Carborundum

See Grinding Wheels.

Carborundum Paper and Cloth

Carborundum Co., Niagara Falls, N. Y.

Case-Hardening

Rogers & Hubbard Co., Middletown, Conn.
Williams & Co., J. H., Brooklyn, N. Y.

Cast Iron Brazing

Industrial Oxygen Co., New York.
Reinforced Brazing & Mach. Co., Pittsburg, Pa.

Castings, Brass and Bronze

Lumen Bearing Co., Buffalo, N. Y.
Rowell Co., W. G., Bridgeport, Ct.

Castings, Die Molded

Franklin Mfg. Co., H. H., Syracuse, N. Y.

Castings, Iron

Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Carr & Co., Stuart R., Baltimore, Md.
Cell Drier Machine Co., Taunton, Mass.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Keystone Steel Casting Co., Chester, Pa.

Castings, Steel

Bethlehem Steel Co., So. Bethlehem, Pa.
Birdsboro Steel Fdry. & Mach. Co., Birdsboro, Pa.
Cammel, Laird & Co., New York.
Curtis & Co. Mfg. Co., St. Louis, Mo.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Keystone Steel Casting Co., Chester, Pa.
Witteman & Co., A. P., Phila., Pa.

Cement, Cast Steel

Clark Cast Steel Cement Co., Shelton, Conn.

Centering Machines
Hendey Mach. Co., Torrington, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Whiton Mach. Co., D. E., New London, Conn.

Centers, Planer
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Woodward & Powell Planer Co., Worcester, Mass.

Chains, Driving
Baldwin Chain & Mfg. Co., Worcester, Mass.
Boston Gear Works, Norfolk Downs, Mass.
Diamond Chain & Mfg. Co., Indianapolis, Ind.
Link-Belt Co., Philadelphia, Pa.
Morse Chain Co., Ithaca, N. Y.
Whitney Mfg. Co., Hartford, Ct.

Chisels, Cold
Hammacher, Schlemmer & Co., New York.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Chucking Machines
American Tool Wks. Co., Cin., O.
Bardons & Oliver, Cleveland, O.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Automatic Machine Co., Cleveland, O.
Gisholt Mach. Co., Madison, Wis.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Manning, Maxwell & Moore, Inc., New York.
Reed Co., F. E., Worcester, Mass.
Warner & Swasey Co., Cleveland, Ohio.
Whitcomb-Blaisdell Machine Tool Co., Worcester, Mass.

Chucks, Drill
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Brown & Co., R. H., New Haven, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Cushman Chuck Co., Hartford, Conn.
Grönkvist Drill Chuck Co., Jersey City, N. J.
Horton & Son Co., E., Windsor Locks, Conn.
Jacobs Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Standard Tool Co., Cleveland, O.
Trump Bros. Mach. Co., Wilmington, Del.
Westcott Chuck Co., Oneida, N. Y.
Whitney Mfg. Co., Hartford, Ct.
Whiton Mach. Co., D. E., New London, Conn.
Wiley & Russell Mfg. Co., Greenfield, Mass.

Chucks, Lathe
Cushman Chuck Co., Hartford, Conn.
Gisholt Mach. Co., Madison, Wis.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Horton & Son Co., E., Windsor Locks, Conn.
Niles-Bement-Pond Co., New York.
Pratt Chuck Co., Frankfort, N. Y.
Skinner Chuck Co., New Britain, Conn.
Union Mfg. Co., New Britain, Ct.
Westcott Chuck Co., Oneida, N. Y.
Whiton Mach. Co., D. E., New London, Conn.

Chucks, Planer
Niles-Bement-Pond Co., New York.
Skinner Chuck Co., New Britain, Conn.
Westcott Chuck Co., Oneida, N. Y.

Chucks, Split
Hardinge Bros., Chicago, Ill.
Rivett Lathe Mfg. Co., Boston, Mass.
Westcott Chuck Co., Oneida, N. Y.

Circuit Breakers
Crocker - Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, Ohio.
General Electric Co., New York.
Western Electric Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Clamps
Billings & Spencer Co., Hartford, Conn.
Hoggson & Pettis Mfg. Co., New Haven, Conn.
Le Count, Wm. G., So. Norwalk, Conn.
Starrett Co., L. S., Athol, Mass.
Tudor Mfg. Co., Taunton, Mass.
Williams & Co., J. H., Brooklyn, N. Y.

Clutches, Friction
Caldwell, Son & Co., H. W., Chicago, Ill.
Cowanesque Valley Iron Wks., Cowanesque, Pa.
Eastern Machinery Co., New Haven, Conn.
Evans Friction Cone Co., Newton Centre, Mass.
Johnson Mach. Co., Carlyle, Hartford, Conn.
Link-Belt Co., Philadelphia, Pa.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.

Clutches, Magnetic
Electric Controller & Supply Co., Cleveland, Ohio.

Coal Handling Machinery
Link-Belt Co., Philadelphia, Pa.

Coils
Standard Welding Co., Cleveland, Ohio.

Collets and Attachments, Spring
Adjustable Collet Co., Cleveland, Ohio.

Compound, Core
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.

Compound, Pipe Joint
Dixon Crucible Co., Joseph, Jersey City, N. J.

Compressors, Air
Blaisdell Machinery Co., Bradford, Pa.
Blanchard Mach. Co., Cambridge, Mass.
Bury Compressor Co., Erie, Pa.
Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compressor Works, New York.
Curtis & Co. Mfg.. Co., St. Louis, Mo.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Sampson & Co., Geo. H., Boston, Mass.
Spacke Machine Co., F. W., Indianapolis, Ind.

Compressors, Gas
Blaisdell Machinery Co., Bradford, Pa.

Conduit, Interior
Sprague Electric Co., New York.

Cones, Friction
Evans Friction Cone Co., Newton Centre, Mass.

Connecting Rods and Straps
Bethlehem Steel Co., So. Bethlehem, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Contract Work
Blanchard Mach. Co., Cambridge, Mass.
Cell Drier Machine Co., Taunton, Mass.
Ingle Machine Co., Rochester, N. Y.
Manville Bros. Co., Waterbury, Conn.
Merritt, Jos., Hartford, Conn.
Turner Mach. Co., Danbury, Ct.

Controllers and Starters, Electric Motor
Case Mfg. Co., Columbus, O.
Crocker - Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, O.
General Electric Co., New York.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Conveyors, Automatic
Link-Belt Co., Philadelphia, Pa.

Coping Machines
Long & Allstatter Co., Hamilton, Ohio.
Niles-Bement-Pond Co., New York.

Corundum
See Grinding Wheels.

Cotters
Adjustable Collet Co., Cleveland, Ohio.
Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Standard Tool Co., Cleveland, O.
Whitman & Barnes Mfg. Co., Chicago, Ill.

Counterbores
Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.

Counters, Machinery
Veeder Mfg. Co., Hartford, Conn.

Countershafts
Almond Mfg. Co., T. R., Brooklyn, N. Y
Builders Iron Foundry, Providence, R. I.
Coates Clipper Mfg. Co., Worcester, Mass.
Evans Friction Cone Co., Newton Centre, Mass.
LeBlond Mach. Tool Co., R. K., Cincinnati, O.
Manning, Maxwell & Moore, Inc., New York.
Mossberg Wrench Co., Central Falls, R. I.
Norton Grinding Co., Worcester, Mass.
Smith Countershaft Co., Boston, Mass.

Countershafts, Friction
Evans Friction Cone Co., Newton Centre, Mass.
Wilmarth & Morman Co., Grand Rapids, Mich.

Countershafts, Speed Changing
Evans Friction Cone Co., Newton Centre, Mass.
Gisholt Mach. Co., Madison, Wis.

Counting and Printing Wheels
Franklin Mfg. Co., H. H., Syracuse, N. Y.

Couplers, Hose
Ingersoll-Rand Co., New York.

Couplings, Shaft
Almond Mfg. Co., T. R., Brooklyn, N. Y.
Caldwell & Son Co., H. W., Chicago, Ill.
Davis Machine Co., W. P., Rochester, N. Y.
Link-Belt Co., Philadelphia, Pa.
Manning, Maxwell & Moore, Inc., New York.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Standard Gauge Steel Co., Beaver Falls, Pa.

Cranes
Box & Co., Alfred, Phila., Pa.
Brown Hoisting Mach. Co., Cleveland, O.
Case Mfg. Co., Columbus, O.
Chicago Pneumatic Tool Co., Chicago, Ill.
Cleveland Crane & Car Co., Wickliffe, O.
Crescent Forgings Co., Oakmont, Pa.
Curtis & Co. Mfg. Co., St. Louis, Mo.

Cranes—*Continued.*
General Pneumatic Tool Co., Montour Falls, N. Y.
Manning, Maxwell & Moore, Inc., New York.
Maris Bros., Philadelphia, Pa.
Moore Co., Franklin, Winsted, Ct.
Nicholls, Wm. S., New York.
Niles-Bement-Pond Co., New York.
Northern Engineering Works, Detroit, Mich.
Obermayer Co., S., Cincinnati, O.
Pawling & Harnischfeger, Milwaukee, Wis.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Yale & Towne Mfg. Co., New York.

Crank Pin Turning Machines
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Underwood & Co., H. B., Philadelphia, Pa.

Crank Shafts
Bethlehem Steel Co., So. Bethlehem, Pa.
Standard Connecting Rod Co., Beaver Falls, Pa.
Tindel-Morris Co., Eddystone, Pa.

Crucibles
Dixon Crucible Co., Joseph, Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Crushers
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Niles-Bement-Pond Co., New York.
Link-Belt Co., Philadelphia, Pa.

Cupolas, and Ladles, Foundry
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.

Cups and Covers, Oil
Bay State Stamping Works, Worcester, Mass.
Besly & Co., Chas. H., Chicago, Ill.
Lunkenheimer Co., Cincinnati, O.
Winkley Co., Detroit, Mich.

Cups, Grease
Lunkenheimer Co., Cincinnati, O.

Cutters, Milling
Adams Co., Dubuque, Iowa.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Hardinge Bros., Chicago, Ill.
Harrison & Knight Mfg. Co., Newark, N. J.
Ingersoll Milling Mach. Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Nash Company, Geo., New York.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, Jno. M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.
Union Twist Drill Co., Athol, Mass.
Ward & Son, Edgar T., Boston, Mass.
Whitney Mfg. Co., Hartford, Ct.

Cutting-off Machines
Armstrong Bros. Tool Co., Chicago, Ill.
Bignall & Keeler Mfg. Co., Edwardsville, Ill.
Brown & Sharpe Mfg. Co., Providence, R. I.
Davis Machine Co., W. P., Rochester, N. Y.
Hill, Clarke & Co., Inc., Boston, Mass.
Hurlbut-Rogers Mach. Co., South Sudbury, Mass.
Manning, Maxwell & Moore, Inc., New York.
Newton Mach. Tool Wks., Philadelphia, Pa.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Schmitz, August, Dusseldorf, Germany.
Tindel-Morris Co., Eddystone, Pa.
Vandyck Churchill Co., New York.

Cutting-off Tools
Armstrong Bros. Tool Co., Chicago, Ill.

Cutting-off Tools—*Continued.*
Billings & Spencer Co., Hartford, Conn.
Cleveland Twist Drill Co., Cleveland, O.
Fitchburg Machine Works, Fitchburg, Mass.
O. K. Tool Holder Co., Shelton, Conn.
Pratt & Whitney Co., Hartford, Conn.
Western Tool & Mfg. Co., Springfield, O.

Diamond Tools
American Emery Wheel Co., Providence, R. I.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Dickinson, Thos. L., New York.
Safety Emery Wheel Co., Springfield, O.

Dies, Sheet Metal
American Tube & Stamping Co., Bridgeport, Conn.
Bliss Co., E. W., Brooklyn, N. Y.
Consolidated Press and Tool Co., Hastings, Mich.
Ferracute Mach. Co., Bridgeton, N. J.
Globe Machine & Stamping Co., Cleveland, O.
Manville Bros. Co., Waterbury, Conn.

Dies, Sub-Press
Sloan & Chace Mfg. Co., Newark, N. J.
Waltham Machine Works, Waltham, Mass.

Dies, Threading, Openi
Errington, F. A., New York.
Foote-Burt Co., Cleveland, O.
Geometric Tool Co., New Haven, Conn.
Jones & Lamson Machine Co., Springfield, Vt.
Pratt & Whitney Co., Hartford, Conn.

Dowel Pins
Winkley Co., Hartford, Conn.

Drawing Boards and Tables
Alteneder & Son, Theo., Philadelphia, Pa.
Artisans Guild, Benton Harbor, Mich.
Kolesch & Co., New York.
Mittineague Paper Co., Mittineague, Mass.

Drawing Materials
Alteneder & Son, Theo., Philadelphia, Pa.
Kolesch & Co., New York.
Mittineague Paper Co., Mittineague, Mass.
Technical Supply Co., Scranton, Pa.

Drafting Machines
Universal Drafting Mach. Co., Cleveland, O.

Drilling Machines, Bench
American Watch Tool Co., Waltham, Mass.
Barnes Co., W. F. & John, Rockford, Ill.
Boynton & Plummer, Worcester, Mass.
Ingersoll-Rand Co., New York.
Manning, Maxwell & Moore, Inc., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentice Bros. Co., Worcester, Mass.
Rockford Drilling Mach. Co., Rockford, Ill.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
U. S. Electrical Tool Co., Cincinnati, O

Drilling Machines, Boiler
American Tool Works Co., Cin., O.
Bickford Drill & Tool Co., Cincinnati, O.
Boynton & Plummer, Worcester, Mass.
Foote-Burt Co., The, Cleveland, O.
Ingersoll-Rand Co., New York.
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.

Drilling Machines, Electric
Chicago Pneumatic Tool Co., Chicago, Ill.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.
Independent Pneumatic Tool Co., Chicago, Ill.

Drilling Machines, Multiple Spindle
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, Rockford, Ill.
Baush Mach. Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Flather Planer Co., Mark, Nashua, N. H.
Foote-Burt Co., The, Cleveland, Ohio.
Fosdick Mach. Tool Co., Cin., O.
Hardinge Bros., Chicago, Ill.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Newton Mach. Tool Works, Inc., Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Slate Machine Co., Dwight, Hartford, Conn.
Taylor & Fenn Co., Hartford, Ct.

Drilling Machines, Portable
Cincinnati Elec. Tool Co., Cin., O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Gem Mfg. Co., Pittsburg, Pa.
Hisey-Wolf Mach. Co., Cin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drilling Machines, Radial
American Tool Wks. Co., Cin., O.
Baush Mach. Tool Co., Springfield, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Dreses Mach. Tool Co., Cin., O.
Fitchburg Machine Works, Fitchburg, Mass.
Foote-Burt Co., Cleveland, O.
Fosdick Mach. Tool Co., Cin., O.
Gang Co., Wm. E., Cincinnati, O.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Hill, Clarke & Co., Inc., Boston, Mass.
Manning, Maxwell & Moore, Inc., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Morris Foundry Co., Jno. B., Cincinnati, Ohio.
Mueller Mach. Tool Co., Cin., O.
Niles-Bement-Pond Co., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Vandyck Churchill Co., New York.
Wormer Mchy. Co., C. C., Detroit, Mich.

Drilling Machines, Turret
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.

Drilling Machines, Upright
American Tool Wks. Co., Cin., O.
Baker Bros., Toledo, O.
Barnes Co., W. F. & John, Rockford, Ill.
Beaman & Smith Co., Prov., R. I.
Boynton & Plummer, Worcester, Mass.
Cincinnati Mach. Tool Co. Cincinnati, O.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.

Drilling Machines, Upright—*Continued.*
Davis Machine Co., W. P., Rochester, N. Y.
Fosdick Mach. Tool Co., Cin., O.
Foote-Burt Co., Cleveland, O.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Henry & Wright Mfg. Co., Hartford, Conn.
Hill, Clarke & Co., Inc., Boston, Mass.
Hoefer Mfg. Co., Freeport, Ill.
Kern Machine Tool Co., Cincinnati, O.
Knight Machry. Co., W. B., St. Louis, Mo.
Manning, Maxwell & Moore, Inc., New York.
Marshall & Huschart Machry. Co., Chicago, Ill.
McCabe, J. J., New York.
Mechanics Machine Co., Rockford, Ill.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
New Haven Mfg. Co., New Haven, Conn.
Niles-Bement-Pond Co., New York.
Patterson, Gottfried & Hunter, Ltd., New York.
Prentice Bros. Co., Worcester, Mass.
Prentiss Tool & Supply Co., New York.
Rockford Drilling Mach. Co., Rockford, Ill.
Sellers & Co., Inc., Wm., Philadelphia, Pa.
Sibley Machine Tool Co., South Bend, Ind.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Taylor & Fenn Co., Hartford, Conn.
Vandyck Churchill Co., New York.
Whitney Mfg. Co., Hartford, Ct.
Wiley & Russell Mfg. Co., Greenfield, Mass.
Wormer Mchry. Co., C. C., Detroit, Mich.

Drills, Center
Cleveland Twist Drill Co., Cleveland, Ohio.
Morse Twist Drill & Machine Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Slocomb Co., J. T., Prov., R. I.
Standard Tool Co., Cleveland, O.

Drills, Hand
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Coates Clipper Mfg. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll-Rand Co., New York.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cincinnati, O.

Drills, Pneumatic
Chicago Pneumatic Tool Co., Chicago, Ill.
Clayton Air Compressor Works, New York.

Drills, Rail
Foote-Burt Co., Cleveland, O.
General Pneumatic Tool Co., Montour Falls, N. Y.
Ingersoll-Rand Co., New York.
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Prentiss Tool & Supply Co., New York.
Standard Tool Co., Cleveland, O.

Drills, Ratchet
Armstrong Bros. Tool Co., Chicago, Ill.
Billings & Spencer Co., Hartford, Conn.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Cleveland Twist Drill Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cin., O.
Manning, Maxwell & Moore, Inc., New York.
Parker Co., Chas., Meriden, Conn.
Pratt & Whitney Co., Hartford, Conn.
Rogers Works, John M., Gloucester City, N. J.
Standard Tool Co., Cleveland, O.

Drills, Rock
Ingersoll-Rand Co., New York.
Northern Electrical Mfg. Co., Madison, Wis.

Drill Speeder
Graham Mfg. Co., Providence, R. I.

Drying Apparatus
American Blower Co., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Dynamos
Burke Electric Co., Erie, Pa.
C & C Electric Co., New York.
Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Roth Bros. & Co., Chicago, Ill.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Electric Co., Cincin., O.
Western Electric Co., Chicago, Ill.
Westinghouse Elec. & Mfg. Co., Pittsburg, Pa.

Electrical Supplies
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Crocker - Wheeler Co., Ampere, N. J.
Electric Controller & Supply Co., Cleveland, Ohio.
General Electric Co., New York.
Jantz & Leist Elec. Co., Cin., O.
Northern Elec. Mfg. Co., Madison, Wis.
Roth Bros. & Co., Chicago, Ill.
Sprague Elec. Co., New York.
Triumph Electric Co., Cincin., O.
Wagner Elec. Mfg. Co., St. Louis, Mo.
Western Electric Co., Chicago, Ill.
Weston Elec. Instrument Co., Newark, N. J.
Westinghouse Elec. & Mfg. Co. Pittsburg, Pa.

Electrically Driven Tools and Machinery
American Tool Wks. Co., Cin., O.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Cincinnati Electrical Tool Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Crescent Forgings Co., Oakmont, Pa.
Electric Controller & Supply Co., Cleveland, O.
Hisey-Wolf Mach. Co., Cincin., O.
Manning, Maxwell & Moore, Inc., New York.
Roth Bros. & Co., Chicago, Ill.
U. S. Electrical Tool Co., Cincinnati, O.
Western Electric Co., Chicago, Ill.

Elevators
Albro-Clem Elevator Co., Philadelphia, Pa.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Link-Belt Co., Philadelphia, Pa.

Emery Wheels
See Grinding Wheels.

Emery Wheel Dressers
American Emery Wheel Co., Providence, R. I.
Bay State Stamping Co., Worcester, Mass.
Desmond-Stephan Mfg. Co., Urbana, O.
Diamond Saw & Stamping Works, Buffalo, N. Y.
Dickinson, Thos. L., New York.
Safety Emery Wheel Co., Springfield, O.
Standard Tool Co., Cleveland, O.
Vitrified Wheel Co., Westfield, Mass.
Wrigley Co., Thos., Chicago, Ill.

Enclosures, Tool-Room
Hart & Cooley Co., New Britain, Conn.
Merritt & Co., Philadelphia, Pa.

Engineering Appliances
Crosby Steam Gage & Valve Co., Boston, Mass.
Lunkenheimer Co., Cincinnati, O.

Engineers, Mechanical and Electrical
Crocker - Wheeler Co., Ampere, N. J.
Merritt, Jos., Hartford, Conn.
Seaver, John W., Cleveland, O.

Machine Department

Chain Department

Miscellaneous Department

We are now well settled in our New Factory and

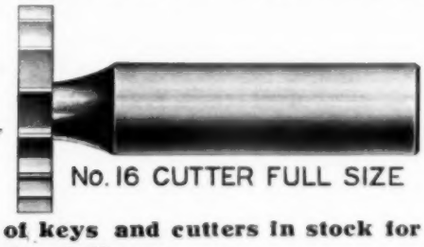
Ready to Show Results

Prompt Delivery and Constant Improvement in Quality

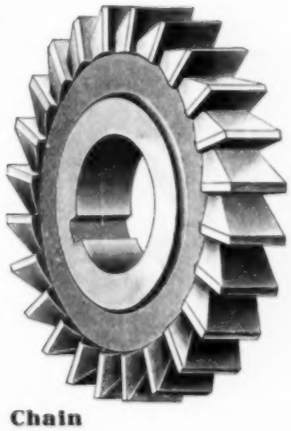
In our effort to possess the Finest Chain Plant in existence and to maintain the highest degree of Accuracy, Efficiency and Finish we are going to the very limit.

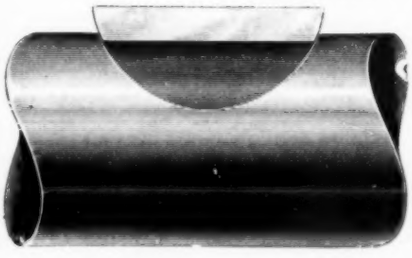
We will now make all sizes of Roller and Bushing Chains for which there is a reasonable demand.

"WHITNEY" MACHINE KEYS and KEY-SEAT CUTTERS
(For the Woodruff Patent System of Keying)

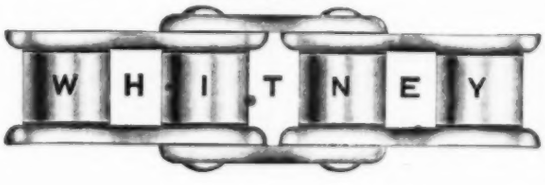


We carry 95 regular Sizes of keys and cutters in stock for immediate delivery.

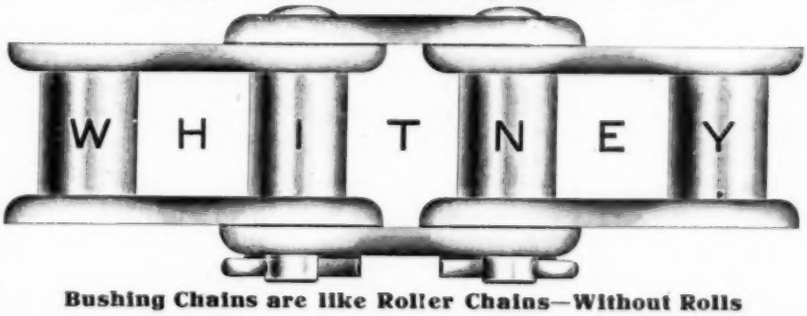




Roller Chain



"Whitney" Detachable Bushing Chain—Patented



Bushing Chains are like Roller Chains—Without Rolls

The Whitney Mfg. Co.

Hartford, Conn.

Engines, Gas and Gasolene
Automatic Mach. Co., Bridgeport, Conn.
Backus Water Motor Co., Newark, N. J.
Blaisdell Machinery Co., Bradford, Pa.
Grant Mfg. & Mach. Co., Bridgeport, Conn.
Olds Gas Power Co., Lansing, Mich.
Struthers-Wells Co., Warren, Pa.

Engines, Motor
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Olds Gas Power Co., Lansing, Mich.
Ridgway Dynamo & Engine Co., Ridgway, Pa.

Engines, Steam
American Blower Co., Detroit, Mich.
Struthers-Wells Co., Warren, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Engraving Machinery
Gorton Mach. Co., Geo., Racine, Wis.

Exhaust Heads
Sturtevant Co., B. F., Hyde Park, Mass.

Exhibition Machinery
Philadelphia Bourse, Phila., Pa.

Expanders, Tube
Nicholson & Co., W. H., Wilkes-Barre, Pa.

Factory Equipment
Lyon Metallic Mfg. Co., Aurora, Ill.
Mfg. Equipment & Eng. Co., Boston, Mass.

Fans, Electric
Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York.
Northern Elec. Mfg. Co., Madison, Wis.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Western Electric Co., Chicago, Ill.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

Fans, Exhaust
American Blower Co., Detroit, Mich.
Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., Phila., Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

Files and Rasps
American Swiss File & Tool Co., New York.
Barnett Co., G. & H., Phila., Pa.
Carver File Co., Philadelphia, Pa.
Hammacher, Schlemmer & Co., New York.
Heller Bros. Co., Newark, N. J.
Nicholson File Co., Prov., R. I.
Reichhelm & Co., E. P., New York.

Filler, Iron
Clark Cast Steel Cement Co., Shelton, Conn.
Felton, Sibley & Co., Phila., Pa.

Filing Machines
Cochrane-Bly Co., Rochester, N. Y.
Henry & Wright Mfg. Co., Hartford, Conn.

Flexible Shafts
Chicago Flexible Shaft Co., Chicago, Ill.
Coates Clipper Mfg. Co., Worcester, Mass.
Gem Mfg. Co., Pittsburg, Pa.
Manning, Maxwell & Moore, Inc., New York.

Forges
Boynton & Plummer, Worcester, Mass.
Bradley & Son, C. C., Syracuse, N. Y.
Burke Machy. Co., Cleveland, O.
Ingersoll-Rand Co., New York.
Miner & Peck Mfg. Co., New Haven, Conn.
National Machinery Co., Tiffin, O.
Prentiss Tool & Supply Co., New York.

Forges—*Continued.*
Sturtevant Co., B. F., Hyde Park, Mass.

Forgings, Drop
Bethlehem Steel Co., So. Bethlehem, Pa.
Billings & Spencer Co., Hartford, Conn.
Brown & Co., R. H., New Haven, Conn.
Crescent Forgings Co., Oakmont, Pa.
O. K. Tool Holder Co., Shelton, Conn.
Williams & Co., J. H., Brooklyn, N. Y.

Forgings, Hydraulic
Bethlehem Steel Co., So. Bethlehem, Pa.

Forgings, Machine
Dyson & Sons, Jos., Cleveland, O.

Forgings, Steel
Bethlehem Steel Co., So. Bethlehem, Pa.
Cammel, Laird & Co., New York.
Crescent Forgings Co., Oakmont, Pa.
Tindel-Morris Co., Eddystone, Pa.
Witteman & Co., A. P., Phila., Pa.

Foundry Furnishings
Adams Co., Dubuque, Iowa.
Goldschmidt Thermit Co., New York.
Ingersoll-Rand Co., New York.
Obermayer Co., S., Cincinnati, O.
Paxson Co., J. W., Phila., Pa.
Stevens, F. B., Detroit, Mich.
Sturtevant Co., B. F., Hyde Park, Mass.

Furnaces, Annealing and Tempering
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Tate, Jones & Co., Pittsburg, Pa.
Westmacott Gas Furnace Co., Providence, R. I.
Witteman & Co., A. P., Phila., Pa

Furnaces, Enameling
American Gas Furnace Co., New York.

Furnaces, Gas
American Gas Furnace Co., New York.
Chicago Flexible Shaft Co., Chicago, Ill.
Nash Company, Geo., New York.
Obermayer Co., S., Cincinnati, O.
Westmacott Gas Furnace Co., Providence, R. I.

Furnaces, Melting
American Gas Furnace Co., New York.
Nash Company, Geo., New York.
Westmacott Gas Furnace Co., Providence, R. I.

Furnaces, Oil
Tate, Jones & Co., Pittsburg, Pa.

Furniture, Machine Shop
Hart & Cooley Co., New Britain, Conn.
Lyon Metallic Mfg. Co., Aurora, Ill.
Manufacturing Equip. & Engineering Co., Boston, Mass.
Merritt & Co., Philadelphia, Pa.
New Britain Mach. Co., New Britain, Conn.

Gages, Recording
Bristol Co., Waterbury, Conn.

Gages, Standard
Ames & Co., B. C., Waltham, Mass.
Athol Machine Co., Athol, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cleveland Twist Drill Co., Cleveland, O.
Grönkvist Drill Chuck Co., Jersey City, N. J.
Henry & Wright Mfg. Co., Hartford, Conn.
Morse Twist Drill & Mach. Co., New Bedford, Mass.
Pratt & Whitney Co., Hartford, Conn.
Rogers Wks., Jno. M., Gloucester City, N. J.
Slocomb Co., J. T., Prov., R. I.
Starrett Co., L. S., Athol, Mass.
Wyke & Co., J., East Boston, Mass.

Gages, Steam
Bristol Co., Waterbury, Conn.
Crosby Steam Gage & Valve Co., Boston, Mass.

Gear Cutting Machinery
Adams Co., Dubuque, Iowa.
American Watch Tool Co., Waltham, Mass.
Becker-Brainard Milling Machine Co., Hyde Park, Mass.
Bickford Drill & Tool Co., Cincinnati, O.
Bilgram, Hugo, Philadelphia, Pa.
Brown & Sharpe Mfg. Co., Providence, R. I.
Clough, R. M., Tolland, Conn.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fellows Gear Shaper Co., Springfield, Vt.
Flather Mfg. Co., E. J., Nashua, N. H.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Manning, Maxwell & Moore, Inc., New York.
Newton Machine Tool Works, Philadelphia, Pa.
Niles-Bement-Pond Co., New York.
Pratt & Whitney Co., Hartford, Conn.
Prentiss Tool & Supply Co., New York.
Slate Machine Co., Dwight, Hartford, Conn.
Sloan & Chace Mfg. Co., Newark, N. J.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Walcott & Wood Mach. Tool Co., Jackson, Mich.
Whiton Machine Co., D. E., New London, Conn.

Gear Testing Machinery
Gisholt Mach. Co., Madison, Wis.

Gears, Cut
Bilgram, Hugo, Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Caldwell & Son Co., H. W., Chicago, Ill.
Chicago Raw Hide Mfg. Co., Chicago, Ill.
Davis, Rodney, Philadelphia, Pa.
Earle Gear & Machine Co., Philadelphia, Pa.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fawcus Mach. Co., Pittsburg, Pa.
Fellows Gear Shaper Co., Springfield, Vt.
Flather Mfg. Co., E. J., Nashua, N. H.
Foote Bros. Gear & Machine Co., Chicago, Ill.
Gleason Works, Rochester, N. Y.
Gould & Eberhardt, Newark, N. J.
Grant Gear Wks., Boston, Mass.
Hardinge Bros., Chicago, Ill.
Harrington, Son & Co., Edwin, Philadelphia, Pa.
Horsburgh & Scott Co., The, Cleveland, Ohio.
Lea Equipment Co., New York.
Mutual Machine Co., Hartford, Conn.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Patterson, Gottfried & Hunter, Ltd., New York.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Wks., Cleveland, O.
Spacke Mach. Co., F. W., Indianapolis, Ind.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.
Walcott & Wood Mach. Tool Co., Jackson, Mich.
Waterbury Gear Co., Waterbury, Conn.

Gears, Molded
Caldwell & Son Co., H. W., Chicago, Ill.
Farrel Fdry. & Mach. Co., Ansonia, Conn.
Franklin Mfg. Co., H. H., Syracuse, N. Y.
Horsburgh & Scott Co., Cleveland, Ohio.
Philadelphia Gear Works, Philadelphia, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.

Gears, Rawhide
Boston Gear Works, Norfolk Downs, Mass.
Chicago Raw Hide Mfg. Co., Chicago, Ill.
Earle Gear & Mach. Co., Philadelphia, Pa.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Grant Gear Works, Boston, Mass.
Horsburgh & Scott Co., Cleveland, O.
New Process Rawhide Co., Syracuse, N. Y.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Sawyer Gear Works, Cleveland, O.

Gears, Worm
Albro-Clem Elevator Co., Philadelphia, Pa.
Boston Gear Works, Norfolk Downs, Mass.
Eberhardt Bros. Mach. Co., Newark, N. J.
Fawcus Mach. Co., Pittsburg, Pa.
Gould & Eberhardt, Newark, N. J.
Horsburgh & Scott Co., Cleveland, Ohio.
Nuttall Co., R. D., Pittsburg, Pa.
Philadelphia Gear Works, Philadelphia, Pa.
Taylor-Wilson Mfg. Co., McKees Rocks, Pa.
Van Dorn & Dutton, Cleveland, O.

Generating Sets
Burke Electric Co., Erie, Pa.
Crocker - Wheeler Co., Ampere, N. J.
General Electric Co., New York
Northern Electric Mfg. Co., Madison, Wis.
Ridgway Dynamo & Engine Co., Ridgway, Pa.
Sprague Electric Co., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Triumph Elec. Co., Cincinnati, O.

Generators, Gas
American Gas Furnace Co., New York.

Gibs
Standard Gauge Steel Co., Beaver Falls, Pa.

Graphite
Dixon Crucible Co., Jos., Jersey City, N. J.
Obermayer Co., S., Cincinnati, O.

Grinders, Knife
American Wood Working Mchy. Co., Rochester, N. Y.
Bridgeport Safety Emery Wheel Co., Bridgeport, Conn.
Safety Emery Wheel Co., Springfield, O.

Grinders, Center
Cincinnati Electrical Tool Co., Cincinnati, O.
Coates Clipper Mfg. Co., Worcester, Mass.
Clark, Jr., Elec. Co., Inc., James, Louisville, Ky.
Gem Mfg. Co., Pittsburg, Pa.
Heald Mach Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cin., O.
Manning, Maxwell & Moore, Inc., New York.
Mueller Machine Tool Co., Cincinnati, O.
Niles-Bement-Pond Co., New York.
U. S. Electrical Tool Co., Cin., O.

Grinders, Cutter
Bath Grinder Co., Inc., Fitchburg, Mass.
Becker-Brainard Milling Mach. Co., Hyde Park, Mass.
Brown & Sharpe Mfg. Co., Providence, R. I.
Cincinnati Milling Machine Co., Cincinnati, O.
Clark, Jr., Elec. Co., Inc., Jas., Louisville, Ky.
Crocker - Wheeler Co., Ampere, N. J.
Garvin Machine Co., New York.
Gould & Eberhardt, Newark, N. J.
Heald Mach. Co., Worcester, Mass.
Hisey-Wolf Mach. Co., Cincin., O.
Ingersoll Milling Mach. Co., Rockford, Ill.
Manning, Maxwell & Moore, Inc., New York.
Niles-Bement-Pond Co., New York.
Norton Grinding Co., Worcester, Mass.